Preschool Obesity in the United Arab Emirates: Determinants and Effectiveness of the Ten Step Healthy Lifestyle Tool for Toddlers: Eat Right Emirates Study

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Declaration

I, Danah Khalid AlTarrah, confirm that the work presented in this thesis is my own. Where information has been derived from other sources, I confirm that this has been indicated appropriately throughout the thesis.

Acknowledgements

Firstly, I would like to thank my supervisors, Prof Atul Singhal and Dr Julie Lanigan for providing me with the opportunity to pursue my chosen PhD project. Your expertise, guidance and unceasing encouragement has moulded me into an independent researcher, and helped me produce work I am very proud of.

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To my fellow PhD friend, Amna Mahmood and dear friend Lama Taher, thank you for sharing this journey with me, I certainly will never forget the highs and lows we have endured together. Saja, my chosen sister, your spontaneous London visits have never failed to brighten my day, thank you for your endless encouragement and support. To my best friend and fiancé, Ali, I can’t thank you enough for your patience, inspirational kind words, and relentless understanding. Thank you for always reminding me that the best is yet to come. To my brother, Fawaz, your invaluable praise, humour, and laughter has fuelled me to the finish line.

My sincere gratitude goes to my parents, Baba, you have inspired me to achieve my goals and learn that ‘if there’s a will there’s a way’. Thank you for believing in me; knowing that I have made you proud is an accomplishment in itself. Mama, I am forever grateful for your unconditional love, support and strength. Our daily calls were the highlight of my day, thank you for lifting me up when I was down, and pushing me to my utmost potential. My love for you two knows no boundaries, this work is dedicated to you.

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Abstract

Childhood obesity has reached epidemic proportions globally, and poses a considerable burden on a child's short- and long-term health. Most obesity presents in the early (preschool) years, and once established tracks into later life. Therefore, identification of risk factors in the preschool period is considered critical for prevention of long-term obesity.

In the United Arab Emirate (UAE), the rising prevalence of childhood obesity is of great public health concern. However, no previous study has explored risk factors for obesity in preschool children. This PhD aimed to: (i) identify risk factors for preschool obesity in the UAE (Study 1); (ii) describe dietary intake and patterns of preschool children, and explore their associations with risk of obesity (Study 2); and (iii) in a randomised controlled trial investigate the effectiveness of the 'Eat Right Emirates' (ERE) tool, a simple leaflet intervention designed to encourage a healthy lifestyle and prevent preschool obesity (Study 3).

Study 1 showed that a longer duration of breastfeeding, and later introduction of complementary foods were associated with lower BMI z-score. **Study 2** found that, compared with UK dietary guidelines, preschool children in the UAE exceeded intakes of protein, but did not meet recommended intakes for fibre. A high carbohydrate intake as a percentage of energy was associated with lower BMI z-score, whereas a high fat intake was associated with higher BMI z-score. A *priori* derived diet score found diets of preschool children were suboptimal, and principal component analysis identified three dietary patterns ('traditional/health-conscious', 'processed/western' and 'convenience/snack'), which were not associated with BMI z-score. **Study 3** found that the ERE tool was effective in reducing obesity risk compared to controls at 6-month follow-up. These findings, and the high compliance rate, suggest that the simple intervention is a promising approach for prevention of obesity in the UAE.

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Abbreviations

BIA	Bio electric impedance analysis
BMI	Body Mass Index
CA	Cluster Analysis
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CVD	Cardiovascular Disease
DEXA	Dual Energy X-ray Absorptiometry
DLW	Doubly Labelled Water
DRV	Dietary Reference Values
EAR	Estimated Average Requirement
EE	Energy Expenditure
EI	Energy Intake
EMRO	Eastern Mediterranean Region
ERE	Eat Right Emirates
FFQ	Food Frequency Questionnaire
FSA	Food Standards Agency
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GLM	General Linear Models
HAAD	Health Authority Abu Dhabi
HDL	High Density Lipoprotein
IOTF	International Obesity Taskforce
Kcal	Kilocalories
Kg	Kilograms
NICE	National Institute of Health and Care Excellence
OB	Obesity
OR	Odds Ratio
OWT	Overweight
p	p-value
PCA	Principal Component Analysis
RCT	Randomised Controlled Trial
RNI	Reference Nutrient Intake
RRR	Reduced Rank Regression
SACN	Scientific Advisory Committee on Nutrition
SD	Standard Deviation
SES	Socio-economic status
UAE	United Arab Emirates
UCL	University College London
UK	United Kingdom
WHO	World Health Organisations

Individual contribution

Alongside invaluable support from my supervisors Professor Atul Singhal and Dr Julie Lanigan in developing the research design and aims, I played a key role in carrying out the current research.

Following unforeseen logistic difficulties in conducting the PhD project in Kuwait (home country), I choose to carry out the current study in the United Arab Emirates (UAE). I personally contacted United Arab Emirates University (UAEU), College of Medicine and Health Sciences and presented my research protocol. With the help of Dr Ian Blair (Chairman for the Institute of Public Health), I was able to collaborate with UAEU, and I was appointed two local supervisors, Dr Ayesha Al Dhaheri (Head of the Nutrition and Health Department) and Dr Syed Shah (Institute of Public Health). I applied for ethical approval and with the help of Dr Ayesha Al Dhaheri initiated contact with a preschool in Al Ain.

All questionnaires, food diary, consent forms and parent information sheets were translated to Arabic by myself. The parent information booklet and Eat Right Emirates tool (informative leaflet adopted from the infant and toddler form in the UK) were redesigned and modified by myself to suit the Arabian culture.

I completed training for anthropometric measurements with Dr Jane Williams at the Childhood Nutrition Research Centre, and experienced hands-on training with a trained nurse (Emma Sutton) on the current Optigrow study in Milton Keynes. I also attended a dietary assessment method workshop at the Nutrition Society, and a training session on principal component analysis with Dr Kate Northstone.

I trained all members of the research team (Rawyah Sayed, Nora AlShehhi, Hessa AlSharqi, Afra AlSandi, Al Reem AlShamsi, Mariam AlZaabi). Research assistants were familiarised with all study documents. Training was given in obtaining consent forms, data collection, as well as the documentation of appropriate data in the form of questionnaires. I provided researchers with the World Health Organisation (WHO) guidelines for the measurement of children, and showed the WHO anthropometric training video.

I personally contacted 402 parents of children enrolled at the Emirates National Schools in Al Ain to inform them of the research. A research assistant carried out the randomisation. Therefore, I collected the consent forms, carried out all study measurements with a help of a trained researcher, both blind to study allocation. I entered all the collected data, coded food diaries and entered dietary data into Microdiet. All statistical analyses were completed by myself with some guidance from my supervisors.

Chapter 1 Overview of childhood overweight and obesity

If you can't measure it, you can't manage it - Peter Drucker

1.1 Introduction

Childhood overweight and obesity is a serious public health challenge of the 21st century, affecting developed and developing countries (World Health Organisation, 2013c). This chapter aims to (i) provide an overview of childhood overweight and obesity, including its global prevalence, assessment and consequences; (ii) introduce the United Arab Emirates (UAE) in the context of the nutrition transition; and (iii) systematically review the prevalence of preschool[1] overweight and obesity in the UAE and neighbouring Arabian Gulf countries.

1.2 Global burden of childhood obesity

Obesity has become a worldwide epidemic, and children are amongst the worst affected (Lobstein, 2004). The prevalence of childhood overweight and obesity is rising in all regions, particularly in children under the age of five. It is estimated that 6% (42 million) of children under the age of 5 are overweight, of whom over 35 million live in low and middle-income countries (de Onis et al., 2010). If these trends continue, it is expected that by 2025 the prevalence of overweight children under the age of five will almost double, to 11% (de Onis et al., 2010)

Whilst some evidence indicates that the rate of increase is plateauing in some high-income countries, the prevalence of paediatric obesity remains high and continues to increase in low and middle-income countries (Olds et al., 2011; Wang and Lim, 2012). Obesity has become a particular problem in transitional countries, which have undergone dramatic socio-demographic and economic changes within the past decades (Lobstein et al., 2004; Wang and Lim, 2012). This is clearly evident in oil-producing Arab Gulf countries. Hence, the current research is focused on the UAE, to better understand the reasons behind the dramatic rise in these countries.

[1] With relevance to the study population, throughout this thesis preschool-age refers to 2 to 6 year old children, unless indicated otherwise.

1.3 Definition of obesity

A simple definition of obesity is an accumulation of excess body fat to the extent where it may have adverse health outcomes (World Health Organisation, 2000). The Body Mass Index[2] (BMI), a measure of relative mass calculated using an individual's height and weight, is often used to define adiposity and classify overweight and obesity in both clinical and epidemiological settings (Reilly, 2005; Lakshman et al., 2012).

1.4 Measurement of obesity in childhood

Several techniques can be used to define obesity in children. These range from the simple measurement of BMI, to more sophisticated anthropometric measures that aim to estimate body fat using skinfold thickness, waist circumference and other techniques, including bio-electric impedance analysis and Dual Energy X-ray Absorptiometry scans (Willett, 1998; Cole et al., 2000). The advantages and disadvantages of these different methods are discussed below.

1.4.1 BMI z-scores and growth charts

BMI is a measure of excess weight (relative to height) rather than a measure of 'excess' fat. In childhood, body fat percentage naturally fluctuates with age as children are constantly growing from infancy to adulthood and differs according to sex (Lindsay et al., 2001; Cole et al., 1995). Therefore, in childhood, overweight and obesity are defined using age- and sex-specific BMI scores that use percentiles to account for normal growth, rather than the discrete BMI cut off points used for adults. Gender-specific BMI-for-age z-scores or percentiles[3] are calculated based on the distribution of a reference population. Several growth references based on national or international data of children growing in different countries and conditions are used to define overweight and obesity using age- and sex-specific BMI z-scores or percentile cut-offs. (Reilly, 2002; Must and

[2] Measure of body mass relative to height: calculated using weight in kilograms divided by height in meters squared (kg/m^2).

[3] A percentile is a value of a variable within which a certain percentage of a population falls (e.g. 85^{th}, 95^{th} percentile). The use of percentiles and z-scores is interchangeable. For the purpose of this research, BMI z-scores will be used.

Anderson, 2006) (Table 1-1). At present, the International Obesity Task Force (IOTF), the World Health Organization (WHO) 2006 child growth standards and the WHO 2007 growth reference are recommended for international use (Cole et al., 2000; de Onis et al., 2010). The IOTF cut-offs are based on data from six countries (the Netherlands, Great Britain, Brazil, Hong Kong, Singapore and the USA), which were used to produce BMI centile curves that pass through BMI 25 (overweight) and 30 (obesity) at age 18. Therefore, to define overweight and obesity in children aged between 2 and 18 years, IOTF cut offs are defined and linked to adult BMI cut-offs, compared to the WHO 2006 growth standard and WHO 2007 growth reference that rely on age-sex-specific BMI centiles (85^{th} centile) or standard deviation scores (e.g. +2 SDs) (Cole et al., 2000; Cole and Lobstein, 2012) (Table 1-1).

However, although the IOTF references and cut-offs are widely used in epidemiological studies, they are not recommended when assessing child's growth in clinical settings. The WHO 2006 child growth standards developed using growth data from the WHO Multi Centre Growth Reference Study (MGRS) conducted in six diverse geographical regions (Brazil, Ghana, India, Norway, USA and Oman) to describe growth 'standard' of breastfed children from birth to 5 years of age, living in optimal environmental conditions (World Health Organisation, 2006), and the WHO 2007 growth reference (reconstructed from the 1977 NCHS/WHO references, and supplemented with data from the WHO growth standard to facilitate a smooth transition at 5 years) were chosen for the purpose of this thesis, as they are widely accepted to represent children growing in diverse international settings, and the WHO 2006 child growth standard was developed using data from Oman which neighbours the UAE and shares similar geographical and cultural influences (see section 6.8.1.2) (Cole et al., 2000; World Health Organisation, 2006; de Onis et al., 2009).

1.4.2 Strengths and limitations of BMI, BMI z-scores and growth charts

Although BMI does not directly measure body fat, it is highly correlated with objective measures of body fat (e.g. Dual-Energy X-ray Absorptiometry) (Reilly and Wilson, 2006; de Onis et al., 2010; Boeke et al., 2013). Therefore, due to its practicality and inexpensiveness in large-scale epidemiological studies, BMI is widely used as a proxy measure of adiposity in children and adults (Deurenberg, 2001).

However, BMI has some limitations, because it does not measure excess body fat or differentiate between fat mass and lean mass. An individual with a high fat-free mass and an individual with a high body fat percentage can have the same BMI; therefore BMI should be used with caution in certain builds of people (Must and Anderson, 2006).

The different growth reference data and cut-off points used to define overweight and obesity also have limitations (Cole and Rolland-Cachera, 2002) .This is largely because the lack of universally applicable references and cut-offs makes the comparison of overweight and obesity prevalence across different studies difficult (Flegal et al., 2001). Several studies that have used different growth charts in the same population of children have shown that the prevalence of overweight and obesity varies according to the growth charts used. Flegal et al. (2001) found that the International Obesity Task Force (IOTF) reference underestimated the prevalence of obesity in young children and overestimated it in older US children (Flegal et al., 2001). Likewise, Vidal et al. (2006) found that the use of the US Centers for Disease Control (CDC) growth charts overestimated the prevalence of obesity among Italian preschool children compared to the IOTF reference (Vidal et al., 2006). Ideally, a standardised classification of overweight and obesity would aid global research and help make meaningful comparisons (de Onis and Lobstein, 2010). This is the rationale behind the WHO 2006 growth standard, which can be used in children up to the age of 5 years, and in older children the WHO 2007 growth references are widely recommended for both clinical and epidemiological use.

Overall, BMI age- and sex-specific z-scores or percentiles have emerged as practical and universally applicable indicators for classifying overweight and obesity in childhood, and are useful in identifying those who are at risk of obesity related co-morbidities. However, because there is some reluctance on using BMI, without taking into consideration a direct measure of body fat, many researchers have investigated the use of additional methods, such as adiposity estimation, to assess paediatric obesity.

1.5 Skinfold thickness

Skinfold thickness measures subcutaneous fat at various sites of the body (i.e. biceps, triceps, subscapular and supra-iliac) to estimate total fat-free mass, fat mass and percentage fat mass using prediction equations (Rolland-Cachera, 1993). The use of skinfold thickness is feasible in large population studies due to its non-invasiveness and low cost. However, it only estimates subcutaneous fat and disregards visceral fat using prediction equations. Therefore, measurements may not represent total body fat. Prediction equations used may also not be appropriate for all populations. For instance, prediction equations used to estimate adiposity in prepubescent children are found to have technical errors ranging between 3-5% (Reilly et al., 1995), These errors are particularly evident when measuring skinfold in overly obese individuals, as the callipers may not accurately grip a wide skinfold, or differentiate fat mass from muscle, therefore underestimating actual measurements. Low reproducibility, due to variability between measurements taken by the same (inter) and different researchers (intra), can also potentially introduce bias and render measurements inaccurate (Must et al., 1991).

1.6 Waist circumference

Another frequently used non-invasive and inexpensive measure of adiposity is waist circumference, which measures abdominal fat (visceral fat) (Maffeis et al., 2001; McCarthy and Ashwell, 2006). Several population-specific references for waist circumference (gender-age-specific) have been developed for children (McCarthy and Ashwell, 2006; Bassali et al., 2010). However, these may be inappropriate for use in some ethnic populations, due to differences in body composition. For instance, a BMI range of 20-25 kg/m^2 is associated with the lowest risk of cardiovascular disease in Western populations, whilst a BMI in this range coupled with a high waist circumference is associated with an increased risk of cardiovascular disease in Asians. Thus, for Asians, a lower BMI cut-off (18 kg/m^2) is suggested as a predictor for increased cardiovascular disease risk (Yusuf et al., 2005; Pischon et al., 2008). The combined measurements of waist circumference and BMI have been suggested to predict metabolic risk among both children and adolescents with greater accuracy (Katzmarzyk et al., 2004; Janssen et al., 2005).

Excess fat around the abdomen is one characteristic of metabolic syndrome[4] (Daniels et al., 1999; Despres and Lemieux, 2006). While some researchers have shown that waist circumference is correlated highly with visceral adiposity (r= 0.80) in children (Brambilla et al., 2006), others have reported no significant relationship (Wells and Fewtrell, 2006). Thus, the relationship between waist circumference and abdominal obesity remains inconsistent.

1.7 Sophisticated measures of body composition in children

Other, more accurate, methods used to directly or indirectly measure adiposity include Dual-Energy X-ray Absorptiometry (DEXA), underwater weighing (densitometry), Computed Tomography (CT), body-water dilution techniques and Magnetic Resonance Imaging (MRI) (Table 1-2). These methods are mostly non-invasive (except for densitometry), informative and highly specific. DEXA, for instance, is considered a gold standard measure, which uses low-level radiation to accurately differentiate between fat mass and fat-free mass in soft tissues, and therefore assesses body composition (Sopher et al., 2004). However, although these sophisticated methods are highly expensive, time-consuming, and their use in large-scale studies is limited (Norgan, 2005; Reilly et al., 2010), they remain valuable research tools, and are commonly used to validate anthropometric measurements (Boeke et al., 2013).

[4] Among adults, MetS is defined using at least three cardiovascular risk factors (hypertension, elevated triglycerides, elevated glucose, and low high density cholesterol (HDL)) and central (abdominal) obesity. To date, there is no standard definition of MetS in children (Anderson et al., 2016).

Table 1-1 Summary of BMI for age charts used to classify childhood overweight and obesity

Reference	Data Source	Age, y	Overweight	Obese
UK-WHO (Wright et al., 2010)	WHO 2006 and UK 1990 (>4 y)	0 – 10	≥91st percentile	≥98th percentile
US CDC (Kuczmarski et al., 2002)	US national surveys: NHES II, III, NHANES I, II, III	2 – 20	≥85th percentile	≥95th percentile
WHO child growth standard, 2006 (de Onis et al., 2007)	Multi-Centre Growth Study Brazil, Ghana, Oman, USA, India, Norway	0 – 5	≥+ 2 SD	≥+ 3 SD
WHO growth reference, 2007 (de Onis et al., 2007)	WHO 2006 and NCHS/WHO (>5 y)	5 – 19	≥+ 1 SD	≥+ 2SD
IOTF (Cole et al., 2000)	Brazil, Netherlands, Great Britain, Hong Kong, Singapore, US representative survey data	2 - 18	≥25 kg/m^2	≥30kg/m^2

UK-WHO, United Kingdom, World Health Organization, CDC, Centers for Disease Control and prevention, NHES, National Health Examination Survey, NHANES, National Health and Nutrition Examination Survey, NCHS, National Centre of Health Statistics, IOTF, International Obesity Task Force), SD (Standard deviation), US, United State

Table 1-2 Summary of strengths and limitations of methods for assessing body composition

Method	Strength	Limitation
DEXA	Uses low level of radiation Estimates fat mass, bone-free fat mass and bone minerals Highly reproducible Accurate Minimal subject compliance required	Large equipment Expensive Radiation exposure
Dilution technique	Measures changes in total body water Estimates fat-free mass, fat mass and body fat percentage	Expensive Assumes composition of fat-free mass, which is arbitrarily affected by age, sex and gender
MRI	Accurate Regional and visceral body fat is measured	Expensive High subject compliance
CT	Accurate Regional and visceral body fat is measured	Expensive High subject compliance
Bod Pod	Measures body density Quick Non-invasive Minimal subject compliance needed	Expensive Accuracy in children not established Assumes composition of fat-free mass, which is arbitrarily affected by age, sex and gender
Densitometry	Measures body density Highly reproducible Accurate	High subject compliance Assumes composition of fat-free mass, which is arbitrarily affected by age, sex and gender
BIA	Non-invasive Quick Uses surface electrodes to measure impedance of electrical resistance related to body water.	Caution is warranted when using equation to estimate body fat

DEXA, Dual Energy X-ray Absorptiometry, MRI, Magnetic Resonance Imaging, CT, Computerized Tomography, Bod Pod, Air Displacement plethysmography, Densitometry, Underwater weighing, BIA, Bio-Impedance Analysis

1.8 Consequences of paediatric obesity

The link between childhood obesity and adverse health consequences is well established (Reilly, 2005; Reilly and Kelly, 2011). These can be categorised into short-term (within childhood) and longer-term (effects carried into adulthood) as summarised in Table 1-3 (Han et al., 2010; Juonala et al., 2011).

Table 1-3 Health consequences of paediatric obesity

Short term	Long term
Psychological Low self-esteem Depression	Persistence of overweight and obesity
Cardiovascular Hypertension Left ventricular hypertrophy Atherosclerosis	Persistence of cardiovascular risk factors
Metabolic Type 2 diabetes Insulin resistance Metabolic syndrome	Persistence of metabolic risk factors
Pulmonary Obstructive sleep apnoea Asthma	Asthma and other breathing problems
Orthopaedic Tibia Vara (Blount disease) Slipped capital-femoral epiphysis	Metabolic syndrome
Gastrointestinal Gastroesophageal reflux Hepatic steatosis (Fatty liver disease)	Chronic inflammation
Others Polycystic ovaries Changed onset of puberty	

1.8.1 Short-term consequences during childhood

1.8.1.1 Psychological

Considerable research suggests that obesity during childhood increases the risk of psychological ill health (Reilly et al., 2003; Pulgarón, 2013). Most commonly, obese children and adolescents are found to experience low self-esteem and behavioural problems (Dietz, 1998; Karnik and Kanekar, 2012). A systematic review by Reilly et al. (2003) found that obese children are more prone to experiencing negative psychological/psychiatric outcomes compared to normal weight children. For example, Strauss (2000) reported that 34% of obese girls (white, 13-14 years old) had low self-esteem compared to only 8% of non-obese girls of the same age and ethnicity. These psychological problems are found to slowly reduce the health-related quality of life of overweight/obese children (Schwimmer et al., 2003; Sanders et al., 2015). However, for children under the age of five, the psychological impact of obesity is still unclear, and more substantial evidence is needed (Reilly et al., 2003).

1.8.1.2 Cardiovascular risk factors

Evidence of cardio-metabolic risk factors associated with childhood obesity has been documented extensively (Reilly et al., 2003; Lawlor et al., 2010). Several epidemiologic studies suggest that the prevalence of cardiovascular disease risk factors (CVD) (Reilly et al., 2003; Simmonds et al., 2016), including hypertension; type 2 diabetes, insulin resistance and dyslipidaemia, are rising in tandem with childhood obesity (Steinberger and Daniels, 2003; Ajala et al., 2017). However, whether these risk factors manifest in children under 5 years is unknown.

The presence and clustering of CVD risk factors is more prevalent among obese children and adolescents compared with those of healthy weight (Skinner et al., 2015). For instance, Freedman et al. (2007) found that, as BMI-for-age increased, the risk of having two CVD risk factors increased from 5% (<25th percentile) to 59% (>99th percentile) in 5- to 17-year-old children (Freedman et al., 2007). More recently, Anderson et al. (2016) investigated 'traditional'[5] and 'non-traditional' CVD risk factors in preschool children, and found that obesity was associated with higher insulin (OR= 1.76; 95% CI: 1.05 to 2.94) and high leptin concentrations (OR=8.15; 95% CI: 4.56 to 14.58). The study confirmed earlier findings that the severity of obesity exacerbates metabolic risk factors, such that those with extreme obesity (>99th percentile BMI-for-age) have the greatest risk (Freedman et al., 2007; Anderson et al., 2016)

1.8.1.3 Other potential medical comorbidities

Obesity also contributes to many other medical conditions, such as asthma, non-alcoholic fatty liver, gastrointestinal disorders and orthopaedic problems (Reilly et al., 2003).

Asthma and obesity in children have been linked in many epidemiological studies (Shore and Johnston, 2006; Ali and Ulrik, 2013). Longitudinal research suggests that obesity increases the risk of asthma, and can worsen the condition in those previously diagnosed (Silva et al., 2007), However, given that the nature of this association is not straightforward, more research is needed to understand the mechanisms underlying the relationship between childhood obesity and asthma (Reilly et al., 2003; Pulgaron, 2013).

Obesity is also likely to increase the risk of non-alcoholic fatty liver disease (NFLD) in children (Suano de Souza et al., 2008). Schwimmer et al. (2006) reported a prevalence of 9.6% for fatty liver in obese children aged 2 to 19 years (Schwimmer et al., 2006). Similarly, a cross-sectional study in Isfahan (Iran) reported that the prevalence of fatty liver in 6- to 18-year-old obese children was significantly higher than in children of healthy weight (54% v 1%) (Adibi et al., 2009). However, others have not found a link (Reilly et al., 2003; Pulgaron, 2013).

[5] 'Traditional' risk factors include triglycerides, glucose, insulin, whereas 'non-traditional' risk factors include subclinical inflammation; adipocyte dysfunction measured using biomarkers (leptin, c-reactive protein, adiponectin), which may be important aspects of cardiometabolic risk (Anderson et al., 2016).

A limited number of studies have investigated the association between gastrointestinal problems and paediatric obesity (Malaty et al., 2009; Phatak and Pashankar, 2015). Malaty et al. (2009) reported that gastroesophaegal reflux symptoms (heart burn, vomiting, regurgitation) were diagnosed more frequently in children who were obese (Malaty et al., 2009). Stordal et al. (2006) similarly showed that overweight children were nearly twice as likely to report gastroesophaegal reflux compared to healthy weight children (OR= 1.8; 95% CI: 1.2 to 2.6) (Stordal et al., 2006). However, because most of the evidence is based on studies that recruited children from gastroenterology clinics, without controls, this association remains unclear, especially for young children (Pulgarón, 2013).

Excess weight can also increase stress on the musculoskeletal system (Wills, 2004).Therefore obese children are more likely to have orthopaedic problems, such as bowing of the legs and tibial torsion (Blount's disease), osteoarthritis and fractures in their lower extremities (Wills, 2004; Kessler et al., 2013).

1.8.2 Long-term consequences

The link between childhood obesity and later metabolic alterations in adulthood is widely documented in systematic reviews; (Simmonds et al., 2015; Llewellyn et al., 2016; Ajala et al., 2017). A recent review by Simmonds et al. (2016) reported that obese children and adolescents are five times more likely to be obese in adulthood than their healthy weight peers (pooled OR= 5.21; 95% CI: 4.50 to 6.02) (Simmonds et al., 2016).

In a recent systematic review, Llewellyn et al. (2016) investigated whether childhood obesity (using BMI as an indicator) predicts obesity-related morbidity in adulthood. From 37 studies, Llewellyn and colleagues found that a high BMI during childhood was associated with an increased incidence of diabetes (OR= 1.70; 95% CI 1.3 to 2.22), coronary heart disease (OR= 1.20; 95% CI 1.10 to 1.31) and some cancers during adulthood. Collectively, these systematic reviews suggest that childhood obesity is associated with a moderate increased risk of adverse health complications among adults.

Obesity in early childhood has also been shown to predict the long-term risk of obesity-related diseases (Ajala et al., 2017). Long-term consequences of childhood obesity have been reported in children as young as 5 years of age. For example, a large population-based birth cohort in Finland that followed up 3- to 5-year-old children to the age of 31 years found that BMI during the preschool years was positively associated with BMI, and inversely associated with HDL-cholesterol in adults (Graversen et al., 2015). Although positive associations with blood pressure and glucose concentrations were considered weak, the study suggested that a BMI over the 90th percentile was associated with adult obesity, central obesity and other features of metabolic syndrome (Graversen et al., 2015; Simmonds et al., 2015).

The potential impact of childhood obesity on health in later life is extensive (Simmonds et al., 2015; Llewellyn et al., 2016; Ajala et al., 2017). Not only does obesity impair health-related quality of life, but it also places a substantial economic burden on health care systems, which has been found to range between 2-6% of all health care expenses (Wang et al., 2011). Largely, the increasing prevalence of obesity-related diseases and the associated social and economic costs highlights the importance of understanding and identifying risk factors of obesity in early life, in order to prevent the development of obesity, rather than treating obesity and its related diseases.

This thesis focuses on childhood obesity in the UAE, an area where little is known regarding the determinants of the condition and how best to prevent it. Therefore, the next section will explore the burden of childhood overweight and obesity in the context of the UAE and neighbouring Arab Gulf countries.

1.9 The United Arab Emirates

The United Arab Emirates is an Arab country situated in the Middle East, and is one of six Gulf Cooperation Council (GCC) countries (Qatar, Oman, Saudi Arabia, Bahrain and Kuwait), commonly referred to as the Arabian Gulf countries. Its land covers 83,600 km^2, mostly covered by parched desert. The climate is hot and humid during the summer months (April to September) reaching 50 degrees Celsius, followed by short winter months (December to January), when more than half the annual rainfall takes place (not exceeding 6.5cm)(Food and Agriculture Organisation, 2015).

Figure 1-1 Map of Gulf Corporation Council (GCC) countries (top) and UAE country map (bottom)

On December 2nd 1971, the union of the seven Trucial States in the UAE was established (Figure 1-1)(Central Intelligence Agency, 2013). Today, the UAE is composed of seven Emirates: Abu Dhabi (the capital city), Dubai, Fujairah, Ras Al Khaimah, Ajman, Sharjah and Um Al Quwain. The population of the UAE is 9,157,000, of whom 11% are native Emirati. The remaining 89% include other Arab ethnic groups, South Asians and Iranians (National Bureau of Statistics, 2011) (Table 1-4). Islam is the principal religion practised in the UAE, and Arabic is the official language. However, English is commonly spoken and taught at schools as a second language (Central Intelligence Agency, 2013)

1.9.1 Economic status

Since the oil boom that began 40 years ago, the UAE has undergone vast economic growth and significant export diversification. Presently, the Gross Domestic Product (GDP) of the UAE is 370.3 billion US dollars (World Bank, 2016) and its economy is ranked as the second largest in the Arabian Gulf region, following the Kingdom of Saudi Arabia. Similar to its neighbouring GCC countries, the UAE remains highly reliant on oil revenues. However, in recent years, the government has been rapidly investing oil proceeds in social and health care development (Central Intelligence Agency, 2013) (Table 1-4).

1.9.2 Education and health care

The UAE government caters to the educational needs of all citizens and offers free education from kindergarten to university level. Education is compulsory for all Emirati citizens up to the age of 15 years, and great efforts are implemented to ensure that educational attainments are met through both private and public (governmental) sectors. The UAE Vision 2021 policy focuses on empowering human capital in order to form a diversified, knowledge-based country (Ministry of Health and Prevention, 2015).

Another prime priority is the health sector. Great attention is paid to developing and improving quality of life for all citizens. Recently, the Health Authority of Abu Dhabi (HAAD) initiated a ‘Schools for Health’ programme that partners with schools, parents, teachers and the health care sector, to promote the health and wellbeing of children and adolescents, and to enable the development of healthy behaviours (Health Authority Abu Dhabi, 2011; Ministry of Health and Prevention, 2015).

1.10 Impact of the nutrition transition in the UAE and Arab Gulf countries

Gulf Corporation Council (GCC) countries[6] share similar cultural norms and traditional practices, and have undergone rapid socio-economic and demographic transitions since the oil boom. These changes have simultaneously shifted dietary and physical activity patterns. The ‘nutrition transition’ is a term widely used to describe such changes in diet and lifestyle habits following economic, social and demographic transformations (Popkin, 1993; Drewnowski and Popkin, 1997; Galal, 2003).

Over 100 years ago (before the discovery of oil), the Arabian Gulf region was predominantly populated by a small population of nomads, or inhabitants who adopted a ‘Bedouin lifestyle’. People mainly lived in tents or small mud houses. Their main source of income was through agriculture, fishing, pearl diving or trade, where they employed great skills to withstand the harsh terrain and climate. Food availability was limited to cattle, fish, milk, wheat and dates, and camels or horses were used for transportation purposes.

The most prominent change began following the discovery of oil during the 1960s. The UAE and neighbouring GCC countries underwent rapid growth in household incomes, which coincided with extensive food marketing and widespread availability of processed and ready-made foods. Hence, traditional diets (high in rice and seafood) gradually shifted towards easily accessible ‘Western’ foods (high in saturated fat and sugar, low in dietary fibre, fruits and vegetables). At the same time, the increased use of technological advancements, and higher employment of domestic helpers, drivers and cooks, encouraged

[6] Throughout this thesis these terms Arab Gulf Countries (Kuwait, UAE, Saudi Arabia, Qatar, Oman and Bahrain) and the Gulf Corporation Council GCC are used interchangeably.

sedentary behaviours and reduced physical activity among the whole population (Mehio Sibai et al., 2010; Musaiger et al., 2012b). Together, these changes are likely to favour positive energy and facilitate overweight and obesity in susceptible individuals.

1.10.1 Changes in food consumption patterns

In countries in the Arabian Gulf, the concept of food progressively changed from a 'necessity for nourishment' during the years of scarcity to a symbol of 'affluence and lifestyle pleasures' (Styne, 2005). Traditional diets – high in milk, rice, bread, fish and vegetables – shifted towards Western diets high in red meats, poultry, dairy products, energy-dense snacks (crisps, cakes and chocolate), and sugary drinks. Tea is a customary drink in the region, traditionally consumed unsweetened and accompanied by dates. Now, however, it is commonly sweetened with condensed or evaporated milk *(in a customary drink called chai karak)*.

Increased availability and consumption of food is evident among high-income countries of the Arabian Gulf (Musaiger, 2011b). A recent Food Agriculture Organisation report (2015) showed that between 1965 and 2011, the national per capita energy supply per day (kcal/capita/day) (Figure 1-2), markedly increased by 24% (from 2,587 to 3,215) (Food and Agriculture Organisation, 2015). Moreover, greater access to Western foods was found to triple the consumption of dietary fat as a percentage of energy intake between 1960 and 1990 (Kubena, 2003).

In addition to the impact of the nutrition transition on dietary and physical activity habits as a result of the increased availability and consumption of imported foods, changes in social, economic and environmental factors have been suggested to contribute to obesity in this region (Musaiger et al., 2011b, Musaiger et al., 2012a). These changes include an increased dependence on domestic helpers, fewer people in manual occupations, increased use of private transport, a decline in breastfeeding, increased number of working mothers, and more fast-food outlets and restaurants (Musaiger and Miladi, 2000; Farrag et al., 2017). These changes collectively may explain the increased prevalence of obesity in the UAE and neighbouring countries. However, this area of research is insufficiently studied and more studies are required to further investigate the impact of the nutrition transition on childhood obesity.

1.11 Other factors influencing diet and weight status in the UAE and neighbouring Arab Gulf countries

In addition to the influence of the nutrition transition, cultural and family factors specific to the Arabian Gulf region have been suggested to shape dietary habits, and influence weight status. These include: (i) cultural norms, attitudes and beliefs towards food; (ii) cultural perceptions of weight status; and (iii) traditional/cultural restrictions, particularly affecting women.

Food consumption patterns and practices in the Arabian Gulf region are largely shaped by cultural norms, attitudes, and beliefs. For example, the term ‘Arab hospitality’ is often used to refer to the generosity and closeness between family, friends, and neighbours in the context of food and drink. Social gatherings in Arab countries are mostly associated with sharing food, and it is customary to accept food when offered, thus refusing food and/or drink is frowned upon. In the current obesogenic environment (increased availability of energy dense foods/drinks). these cultural practices have been suggested to drive overconsumption. Thus, these customs and attitudes towards food may partly explain the rising prevalence of overweight and obesity among the whole population.

Perceptions of weight status are also influenced by cultural norms. Within the Arab culture ‘plumpness’ is valued and seen as a sign of prosperity, health and beauty (Kandela, 1999). As a result, many parents do not recognise overweight or obesity in their child. For instance, recent studies have reported that 50% to 90% of parents in the Arabian Gulf region misclassify their overweight/obese child as normal weight (Hashemi, 2009; Hussin et al., 2011; Aljunaibi et al., 2013). This is important because if parents mistakenly believe that their child is a healthy weight, they would neglect to seek help (Al-Mohaimeed, 2016).

Researchers in the region have suggested that women face more cultural barriers or restrictions compared to men. Traditional/cultural restrictions influencing obesity risk in women include; (i) limited access to communal leisure centres and opportunities to partake in physical activity; (ii) traditional clothing often worn by women in the Arabian Gulf region (Abaya or Jalabiya) limiting participation in sporting activities; (iii) the 'looseness' of traditional clothing demotivates women to lose weight (Musaiger and Qashqari, 2005); and (iv) employment of domestic helpers has also been suggested to exacerbate the sedentary lifestyles

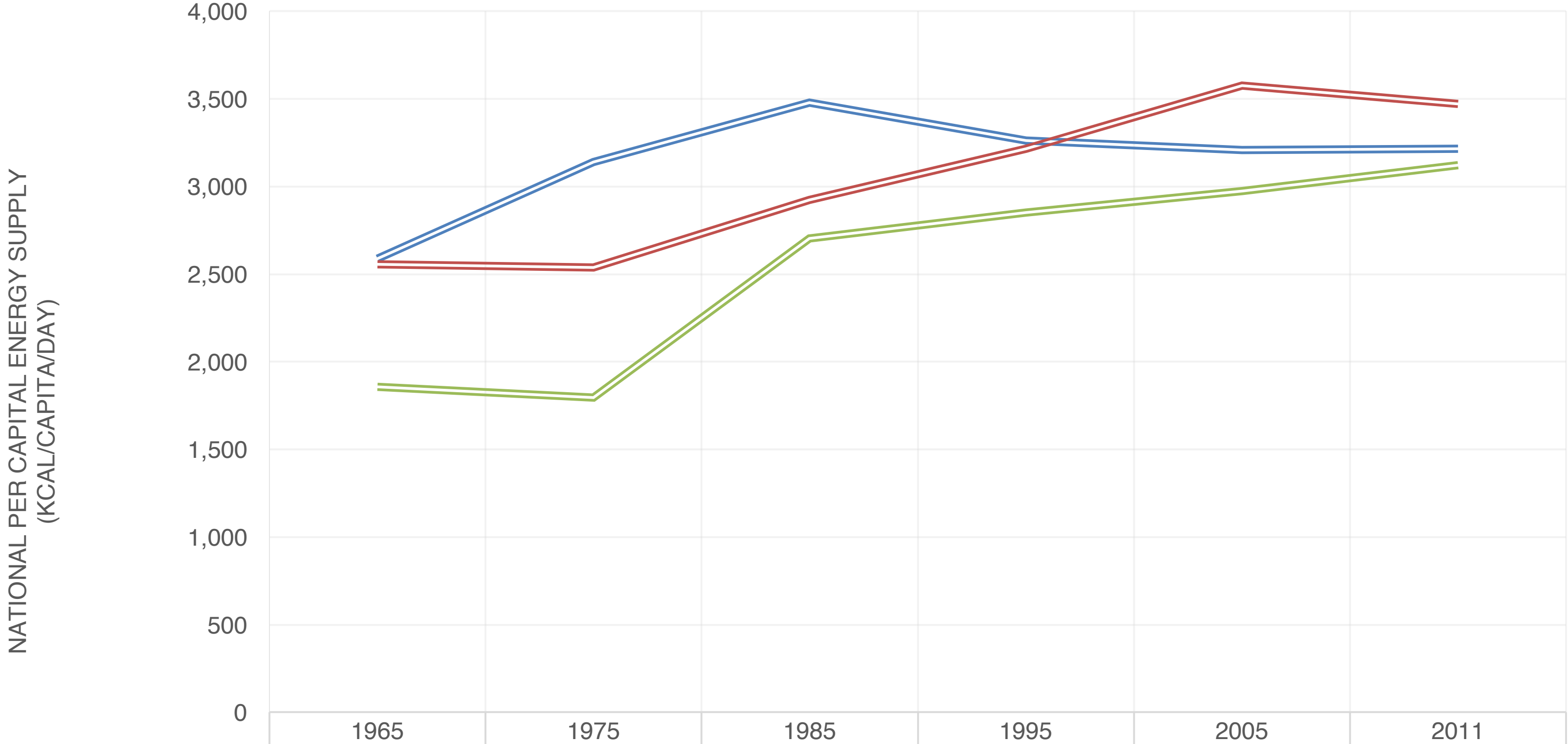
In summary, although these findings suggest that collectively the nutrition transition, cultural factors, and lifestyle changes may have influenced obesity risk, limited research has investigated how these factors contribute to the increasing prevalence of childhood obesity in the UAE and neighbouring Arab Gulf countries.

Table 1-4 Summary of socio-demographic, economic and health care indicators in the UAE

Indicator	Year	Value
Population (total)	2014	9,156,963
Population growth (% annual)	2015	6.1
Life expectancy at birth m/f (years)	2015	76/79
Probability of dying between 15 and 60 years m/f (per 1000 population)	2013	84/59
Population recognised as national (%)	2014	11
Population recognised as non-national (%)	2014	89
GDP ($, billion)	2015	370.3
Gross national income per capita (PPP international $)	2012	58,090
Total expenditure of health per capita (Intl $)	2014	2,405
Total expenditure on health as % of GDP	2014	3.6

(World Bank, 2016)

Figure 1-2 National per capital energy supply for UAE, Kuwait and Saudi Arabia
(FAOstat, 2015)



	1965	1975	1985	1995	2005	2011
United Arab Emirates	2,587	3,141	3,477	3,261	3,210	3,215
Kuwait	2,556	2,538	2,922	3,214	3,576	3,471
Saudi Arabia	1,857	1,795	2,703	2,852	2,973	3,122

1.12 Systematic review of the prevalence of preschool obesity in the United Arab Emirates and neighbouring Arab Gulf Countries

Rapid urbanisation and the adoption of a 'Western' lifestyle have collectively been suggested to contribute to the rising prevalence of obesity in the Arabian Gulf region (Musaiger, 2011b). However, while the prevalence of overweight and obesity in school-aged children, adolescents and adults is well documented (al-Mahroos and al-Roomi, 1999; Musaiger, 2004; Al-Kandari, 2006; bin Zaal et al., 2009; ALNohair, 2014), studies focused on preschool children are scarce. Previous reviews (Mirmiran et al., 2010; Musaiger, 2011b; Farrag et al., 2017) have reported that the prevalence of preschool overweight and obesity is increasing in the Arab Gulf region. However, most of these reviews have included all age groups, and have not focused on the prevalence of obesity in preschool children. Therefore, to enable further understanding of preschool obesity prevalence and the scale of the problem in the UAE and neighbouring Arab Gulf countries, a systematic review was carried out.

The current systematic review includes data from Qatar, Bahrain, Oman, Saudi Arabia, Kuwait and the UAE (Gulf Cooperation Council countries), due to a lack of data on preschool children from the UAE alone. Therefore, the aim of the systematic review was to summarise the current evidence and identify gaps in the research of preschool (2 – 6 year old children) obesity in the UAE and neighbouring Arab Gulf countries.

1.12.1 Methods

1.12.1.1 Search Strategy

A systematic search of the electronic databases MEDLINE (Ovid), EMBASE, and PubMed was carried out to identify all relevant published articles relating to preschool overweight and obesity in the UAE and Arab Gulf countries between January 1990 and July 2016.

The search strategy was developed using the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines (Liberati et al., 2009). A combination of search terms relating to the outcome of interest (overweight, obesity, BMI, body weight, adiposity, fatness), the study population (United Arab Emirates, Kuwait, Kingdom of Saudi Arabia, Qatar, Bahrain, Oman) and the age group (preschool, childhood, toddler, child, kindergarten) were used in the search strategy. An example search strategy using MEDLINE can be found in **Appendix A**. A hand search of reference lists (bibliographies) of included studies was also carried out and relevant experts in the Arab Gulf region were consulted, where possible, to identify any studies omitted by the database search. The Arabic literature was also searched to identify studies published in Arabic.

1.12.1.2 Study selection

The systematic review was conducted following procedures, described in the Cochrane Handbook of Systematic reviews (Higgins and Green, 2011). Cross-sectional studies that assessed the prevalence of overweight or obesity using measures including BMI, BMI z-scores, BMI percentiles, body fat percentage, and skinfold thickness in preschool children were included. The definition of overweight and obesity was not limited to a specific growth reference. Abstracts were screened, and studies that met the inclusion and exclusion criteria described in Table 1-5, were included for full text review (Figure 1-3).

Table 1-5 Inclusion and Exclusion criteria

Inclusion criteria
Published in English and Arabic language
Limited to human studies
Includes objective anthropometric measurements that define overweight and obesity using different BMI-for-age cut-off points
Children between the age of 2 and 6 years
Gulf Cooperation Council countries (UAE, Bahrain, Oman, Qatar, Saudi Arabia, Kuwait)
Exclusion criteria
Other Arab countries (e.g. Iran, Lebanon, Iraq, Palestine, Syria, Yemen, Egypt).
Studies that used parent-reported anthropometric measures
Children outside the included age range

1.12.2 Data extraction

The titles and abstracts of studies were assessed for compliance with the inclusion criteria. An extraction sheet based on the Cochrane Consumers and Communication Review Group's data extraction template was developed and refined to suit the research question (**Appendix B**). Full texts were reviewed in cases where abstracts were not sufficient for screening purposes. Data were extracted from each study including: (i) characteristics of study design and participants; (ii) method used to define overweight and obesity (e.g. BMI using cut off points, and growth reference used). Where preschool children were included as part of a wide age range, data for preschool aged children was extracted. Standard cut-off points used to define overweight and obesity and prevalence were reported as a percentage. Studies that reported the prevalence of overweight and obesity either combined or separately were included, to avoid losing data. In cases where prevalence in males and females was reported separately, the data were included accordingly. Two reviewers (myself and Prof. Atul Singhal) completed all procedures, including data extraction, reporting and interpretation.

1.12.2.1 Quality assessment

The methodological quality of studies included in the current systematic review were assessed using a modified version of the Downs and Black checklist, designed to assess bias in both randomised and non-randomised studies (Downs and Black, 1998). The checklist was modified to include aspects of particular relevance to cross-sectional studies reporting prevalence of overweight and obesity in preschool children aged between 2 and 6 years in the Arabian Gulf region. Questions that referred to randomised and intervention studies were excluded. Therefore, only 10 questions of the possible 28-item checklist were included. Two reviewers independently scored the studies against the modified 10-item checklist, which included questions regarding study reporting (e.g. study objectives), external validity (e.g. representativeness of study population) and internal validity/bias (e.g. appropriateness of statistical tests used) (See Table 1-6 for the modified version). A maximum score of 10 was possible from the questions included in the checklist. Two reviewers discussed discrepancies to achieve agreement. Based on the quality index rating of a previous systematic review using the modified version of the checklist (Muthuri et al., 2014), a score equal to or greater than 7 was interpreted as good/high quality, a score between 4 and 6 was considered moderate quality, and a score below 3 was considered poor. The final assessment of bias was based on this score and consensus between the two reviewers.

Table 1-6 Modified Downs and Black Checklist

(yes 1 / no 0, unable to determine)	Score
REPORTING	
Question 1: Is the hypothesis/aim/objective of the study clearly described?	
Question 2: Are the main outcomes to be measured clearly described in the introduction or methods section?	
Question 3: Are the characteristics of the participants included in the study clearly described?	
Question 6: Are the main findings of the study clearly described?	
Question 7: Does the study provide estimates of the random variability in the data for the main outcomes?	
EXTERNAL VALIDITY	
Question 11: Were the participants asked to participate in the study representative of the entire population from which they were recruited?	
Question 12: Were those participants who were prepared to participate representative of the entire population from which they were recruited?	
INTERNAL VALIDITY – BIAS	
Question 18: Were the statistical tests used to assess the main outcomes appropriate?	
Question 20: Were the main outcome measures used accurate (valid & reliable)?	

1.12.3 Results

1.12.3.1 Study characteristics

Study characteristics of included studies are presented in Tables 1-7 to 1-10, and include name of first author, year of publication, study characteristics (region, sample size and study design), assessment methods and results.

One hundred and seventy-six articles were identified using the search strategy in **Appendix A**. Screening of abstracts and reference lists of included studies identified 46 potentially relevant articles (Figure 1-3). Twenty-four papers were excluded for the following reasons: (i) addressed older age groups; (ii) did not report anthropometry; (iii) were review papers based on key words used in the search strategy. Twenty studies were included for full-text review.

Of the 20 studies included, most (35%) were from Kuwait; six (30%) were from the UAE, of which two were national and four were regional, five (25%) were from Saudi Arabia and, one from Bahrain and one from Qatar. Studies from all GCC countries but one were included in the review. The review included 46,439[7] children, and more than half included more than 1000 preschool children, and the largest population of children was from the Kingdom of Saudi Arabia (12,701 preschool children). Only four studies mainly focused on preschool children aged between 2 and 6 years old, and the remainder also included older school-aged children (range 0 to 19 years old). Data on preschool children (between 2 – 6 years of age) were extracted from these studies and included in the review. In studies where data was limited (e.g. cut-offs used were not clearly described or when preschool children were combined with older children), authors were further contacted to obtain additional information on raw data used to report the prevalence of overweight and obesity[8]. All included studies were published in English, no Arabic literature was found.

All studies were cross-sectional, and included data on overweight and/or obesity. One report was from a governmental study conducted by the Ministry of Health in Kuwait: the Kuwait National Surveillance Study (Al-Qaoud and Prakash, 2009; Al-Qaoud et al., 2010), while three were multicentre cross-sectional studies (al-Isa and Moussa, 1998; Abdulrazzaq et al., 2011; El Mouzan et al., 2012), and the remainder were independent cross-sectional studies.

The most commonly used growth reference was the CDC growth charts, followed by the IOTF. Each study used a different growth reference to define overweight

[7] Three studies did not report number of preschool children (Abulrazzag et al., 2011, Al Rafaee et al., 2013, Elkum et al., 2015).

[8] It was not possible to retrieve raw data from authors due to logistic/ethical constraints raised by the authors.

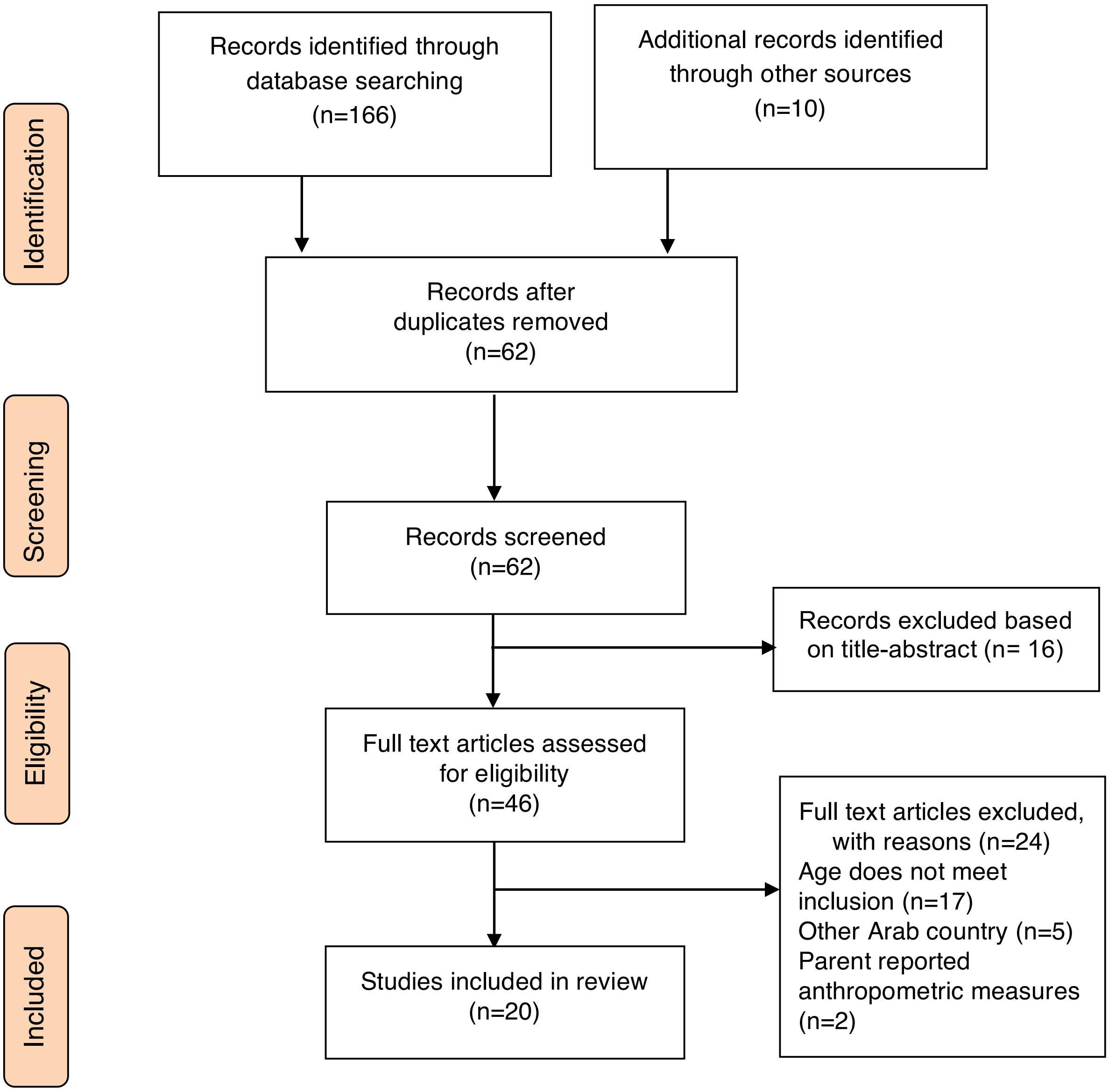
and obesity, three of which used more than one growth reference (Bener and Kamal, 2005; Al-Raees et al., 2009; Elkum et al., 2015; AlBlooshi et al., 2016). AlBlooshi et al. (2016) and Elkum et al. (2015) compared the prevalence of overweight and obesity using the WHO, CDC growth charts and IOTF growth reference.

Of the 20 included studies, 11 (55%) reported prevalence rates for both overweight and obesity, and 4 (20%) reported obesity alone. Seven (35%) additionally reported the prevalence according to gender, of which 4 (20%) only presented data for boys and girls separately, without a combined prevalence of all children included. Two studies (from Saudi Arabia) reported the prevalence of overweight and obesity in different provinces, including both rural and urban cities. Overall, the prevalence of preschool ranged between 4% and 42% for overweight and 2% and 58% for obesity. The combined prevalence of overweight and obesity was lowest in the UAE (2%) and highest in Kuwait (58%).

1.12.3.2 Quality assessment

Most studies were of good/moderate quality (mean index was 6.3, ranging between 5 and 7). Most studies scored poorly on items relating to the representativeness of the study population, the inappropriate use of growth charts (e.g. the use of CDC growth charts instead of the WHO growth reference despite availability at the time of the study), and the cut-offs used for the study population. However, all studies scored well on questions related to reporting of study objectives and outcomes (see, Table1-7 to 1-10).

Figure 1-3 Results of Search Strategy



1.12.4 Discussion

Obesity is a serious problem affecting children from both developed and developing countries (de Onis et al., 2010). The Global Burden of Disease study in 2013 (Ng et al., 2014) reported that overweight and obesity prevalence is greatest in oil-producing Arab Gulf countries. This systematic review confirms findings from previous reviews that found that the obesity prevalence is high and progressively increasing among preschool children in Arab Gulf countries (Musaiger, 2011b; Farrag et al., 2017). However, none of these reviews solely investigated the prevalence of overweight and obesity in preschool children. A review by Musaiger (2011) found the prevalence of preschool obesity to range between 2% and 22%, and elucidated that prevalence is rising among all countries in the region (Musaiger, 2011b). The prevalence of obesity in this systematic review ranged between 2% and 58%, supporting this earlier review and indicating a continuing upward trend.

1.12.4.1 Prevalence of preschool overweight and obesity in the UAE and neighbouring countries

The prevalence of preschool overweight and obesity in the UAE and neighbouring Arabian Gulf countries varied widely. These variations can be explained by: (i) the different age groups studied, (ii) the different growth charts used; (iii) the different study periods; (iv) the different sample sizes; and (v) regions studied. However, although these studies cannot be directly compared, they provide an indication that the prevalence of overweight and obesity is high and rising in the region.

In the UAE, although Al-Haddad et al. (2005) and Malik and Bakir (2007) both used the IOTF reference, Al-Haddad et al. (2005) reported that 8% of children aged 4 to 5 years were overweight. Whereas Malik and Bakir (2007) reported 12% children aged between 5 and 7 years were overweight (Al-Haddad et al., 2005; Malik and Bakir, 2007). The largest multi-centre cross-sectional study in the UAE (n= 21,088 children aged 0 – 5 years) (Abulrazzaq et al., 2011), which used the WHO 2006 growth standard reported a higher prevalence of overweight as 13.5% among girls and 13.0% among boys, compared to earlier studies. These differences could be a result of the different growth charts used and the wide age range of children included in each study. Nevertheless, studies in the UAE suggest that the prevalence of preschool overweight and obesity is increasing, and is consistent with earlier studies suggesting that the prevalence of overweight/obesity among school-aged Emirati children is increasing and surpasses Western countries (bin Zaal et al., 2009).

As in the UAE, the prevalence of obesity among 3–5-year-old Kuwaiti children has increased as much as sevenfold between 1998 (8%) (al-Isa and Moussa, 1998) and 2010 (58%) (Al-Qaoud et al., 2010). However, a more recent large-scale study (n= 6574), that used the WHO growth reference reported that 14% and 20% of 6 year old Kuwaiti children were overweight and obese respectively (Elkum et al., 2015). The varying prevalence rates of preschool overweight and obesity in Kuwait, ranging from 4% to 42% and 8% to 58% respectively, could be a result of the different sample sizes, the wide age groups and the growth charts used. However, since Elkum et al. (2015) employed the WHO growth reference and included a larger representative sample of children, this study could be more representative of the prevalence of preschool overweight and obesity in Kuwait.

Studies from the Kingdom of Saudi Arabia indicate that overweight and obesity in preschool children is rising. El Mouzan et al. (2010) reported that 12.4% and 4.6% of 5 to 6 year old children were overweight and obese respectively. A more recent study by the same author reported a similar but slightly higher prevalence of overweight and obesity (among 2- to 6-year-olds) as 13.4% and 5.9% respectively (El Mouzan et al., 2010; El Mouzan et al., 2012). However, Al Dossary et al., (2010), which used the CDC growth charts reported that 18% and 19% of 2 to 4 year old children were overweight and obese respectively (AlDossary et al., 2010). These studies employed different growth charts (e.g. Al Mouzan et al. (2012) used WHO growth charts, whereas Al Dossary et al., (2010) used the CDC growth charts), and included different age groups. Therefore, it proved difficult to compare studies in Saudi Arabia.

The use of different growth charts and cut-off points limits comparisons between studies. For instance, studies that employ different growth charts in the same population have shown that the prevalence of overweight and obesity varies according to the growth chart used (Flegal et al., 2001). In this current review, two studies found that the use of different growth charts resulted in different prevalence rates. In the UAE, a large-scale study in Ras Al Khaimah city, which used three different reference methods (the IOTF, CDC and WHO growth charts) to define overweight, obesity and extreme obesity, found that the prevalence ranged between 11.5% and 14.2% in children aged between 3 and 6 years (AlBlooshi et al., 2016). Al Raees et al., (2009) that used both the IOTF and WHO references to calculate the prevalence of overweight and obesity in Bahrain, also reported that the prevalence ranged between 7.2% to 9.8% for overweight, and 6.2% and 10.1% for obesity.

However, whilst both studies used the >85th percentile, and >95th percentile to define overweight and obesity with the WHO growth charts, Al Blooshi et al. (2016) and AlRaees et al. (2009) both included children aged between 3 and 6 years, and 2 and 6 years respectively. Therefore, taking into consideration that WHO growth charts are age sensitive (i.e. the WHO 2006 growth chart includes children from birth to 5 years, and the WHO 2007 growth reference includes children aged 5 to 19 years), and cut-offs differ for children younger or older than 5 years of age (see Section 1.4.1). These findings need to be interpreted with caution, since both studies did not clearly address the wide age range of children included. Thus, in agreement with previous studies, these findings highlight that future studies in the region should use a standard growth chart or reference (e.g. WHO 2006 growth standard and WHO 2007 growth reference) to aid comparisons, and better reflect the current prevalence in the Arabian Gulf region (de Onis and Lobstein, 2010; Flegal and Ogden, 2011).

Overall, differences between studies (and within the same countries) make comparisons difficult. These variations include: (i) sample sizes (ranged from 224 to 21,044 children); (ii) the age range studied (e.g. some studies included 2 – 6 year old children, whereas data for 6 year old children was extracted from others that included older children); (iii) methodological differences (i.e. different definitions and references used to define overweight and obesity); (iv) categories reported (e.g. overweight and obesity separately or combined). Further bias introduced from regional variations and gender differences are discussed below.

1.12.4.2 Regional variation

Variations were observed between different provinces in the Kingdom of Saudi Arabia. The review found a higher prevalence of overweight and obesity in urban areas compared to those more rural. For instance, El-Hazmi and Warsy (2002) reported that the prevalence of overweight among preschool boys was six times higher in the Eastern province (urban) compared to the Southern province (rural). Likewise, Al Mouzan et al., (2012) found that the prevalence of overweight and obesity was two times higher in the urban areas (North and Capital), compared to the rural region in the Southwest. Although, these studies did not investigate why such regional differences exist, it could possibly be explained by cultural and socio-economic factors that may influence dietary and lifestyle habits. For example, children living in urban areas are more exposed to energy-dense imported foods (crisps, burgers, chips, fizzy drinks), whereas those residing in rural areas may consume a more traditional diet (high in vegetables, rice, fish and dates) due to the limited exposure and availability of Western foods and drinks. Also, the climate can influence variability between these provinces (El-Hazmi and Warsy, 2002).

In this review regional/provincial differences were only observed in the Kingdom of Saudi Arabia. However, similar differences have been reported in other countries. For example, in Iran, the prevalence of overweight and obesity among children and adolescents ranged between 5% and 11.3% in different provinces (Jafari-Adli et al., 2014). These findings therefore suggest that future studies should include both rural and urban regions, to better inform policies and future measures that aim to prevent childhood overweight and obesity.

1.12.4.3 Gender differences

Overall, overweight and obesity prevalence among preschool children did not vary according to gender. The mean prevalence of overweight was 12.4% and 12.9% for boys and girls respectively.[9] However, gender differences were observed in some studies. For example, the prevalence of overweight in the Central province of Saudi Arabia was 9.5% and 4.2% among girls and boys respectively (El-Hazmi and Warsy, 2002). This was also seen in the UAE, where the combined prevalence of overweight and obesity was significantly higher among girls (AlBlooshi et al., 2016). Gender differences could be explained by cultural norms and attitudes towards nutrition and physical activity. For example, the hindrances faced by girls and women in partaking in physical activity in the Arab Gulf region could increase their risk of becoming overweight/obese (Musaiger, 2004; Musaiger, 2011b).

1.12.5 Strengths and limitations of this review

This review is the first to solely focus on preschool children in the UAE and neighbouring Arab Gulf countries. Although the studies in this review cannot be directly compared, a large number of included studies support the findings of previous systematic reviews by Musaiger (2011) and Mirmiran et al. (2010) and underscore that the prevalence of overweight and obesity among preschool children is evidently high and increasing. Therefore, the magnitude of the obesity problem in the UAE and neighbouring Arab Gulf countries highlights the importance of future research to identify risk factors of preschool obesity, in order to inform interventions to prevent obesity in this region.

Nevertheless, there are several methodological limitations that made the summation of evidence from different studies difficult. These include limited access to research papers, the different periods surveyed and the heterogeneity of studies, including different growth references and cut-offs used to define overweight and obesity and the wide age range of the study population, as

[9] Mean prevalence of overweight using all available data on girls and boys included in the review.

demonstrated in Tables 1-7 to 1-10. A major issue in interpreting and comparing studies is the use of different references and cut-off points to define overweight and obesity among preschool children. Studies included in the review employed different references and cut-off points; thus, the prevalence of overweight and obesity varied widely. The use of different references makes it difficult to monitor trends and make valuable comparisons between studies and within countries. Other constraints were the limited number of studies that focused on preschool children, and the variation in studied age groups, making it impractical to make accurate comparisons. For example, comparing preschool children aged between 4 and 5 years with those aged between 2 and 6 years. Lastly, the limited number of large nationally representative data available, and the cross-sectional nature of all studies, make it difficult to examine the extent of overweight and obesity, and do not allow the estimation of trends over time.

1.12.6 Conclusion

This present review highlights the severity of obesity in preschool children, confirms the need to understand national and regional differences, and emphasises the need for longitudinal studies that would better describe the prevalence of overweight/obesity and its progression over time.

1.13 Chapter summary

In summary, obesity is the accumulation of excess body fat to the degree that health may be impaired in the short and long-term. The obesity epidemic is affecting preschool children worldwide, and as obesity in childhood persists into adulthood. This chapter demonstrates the importance of recognising overweight and obesity during early childhood to prevent progression of obesity-related co-morbidities into later life. Childhood obesity in particular is high and rising in oil-producing transitional countries. However, despite the rising prevalence of preschool obesity in the Arabian Gulf region, this subgroup of the population has received scant attention, and determinants of preschool obesity are seldom studied. A comprehensive understanding of the aetiology of childhood obesity is necessary. Hence, the current research focuses on identifying risk factors of preschool obesity in the UAE, to better inform future interventions to prevent obesity and reduce both the adverse health consequences and economic burden of treatment.

Table 1-7 Characteristics of included studies in the UAE

Author	Study design	Country (region)	Age (y)	Sample size (n) (% male)	Method	Overweight (%)			Obesity (%)			Quality assessment
						All	Boys	Girls	All	Boys	Girls	
1. Al Haddad et al., 2000	Cross sectional	UAE	6	877(47)	NHANES-1	5	-	-	7	-	-	**6**
2. Al Haddad et al., 2005	Cross sectional	UAE	4 – 5	1006 (48)	IOTF	8	-	-	2	-	-	**7**
3. Malik and Bakir, 2007	Cross sectional	UAE (AD)	5 – 7	794 (50)	IOTF	12	-	-	10	-	-	**6**
4. Abdulrazzaq et al., 2011	Multi centre Cross sectional	UAE	0 – 5	21,088 (42) *0-18 y	WHO	-	13.5	13.0	-	6.1	6.5	**7**
5. Al Junaibi et al., 2013	Cross sectional	UAE (AD)	6	451(50)	CDC	-	20.8 [a]	24.8 [a]	-	-	-	**6**
6. Al Blooshi et al., 2016	Population-based Cross sectional	UAE (RAK)	3 – 6	6,731 (49)	IOTF	11.5 [b]	10.4 [b]	12.7 [b]	-	-	-	**7**
					CDC	14.2 [b]	13.3 [b]	15.2 [b]	-	-	-	
					WHO	14.0 [b]	13.0 [b]	15.1 [b]	-	-	-	

UAE, United Arab Emirates, RAK, Ras Al Khaimah, AD, Abu Dhabi, NHANES, National Health and Nutrition Evaluation Survey, IOTF, International Obesity Task Force, CDC, Centers of Disease Control, WHO, World Health Organisation, [a]: overweight and obesity, [b] overweight, obesity and extreme obesity.

Table 1-8 Characteristics of included studies in Kuwait

Author	Study design	Country (region)	Age (y)	Sample size (n) (% male)	Method	Overweight (%)			Obesity (%)			Quality assessment
						All	Boys	Girls	All	Boys	Girls	
7. Al Isa & Moussa et al., 1998	Multi-stage stratified Cross sectional	KUW	3 - 5	7149 (52)	NCHS/ CDC	-	-	-	8	-	-	**5**
8. Moussa et al., 1999	Cross sectional	KUW	6	270 (53)	NCHS	-	-	-	-	1.6	1.5	**6**
9. Al Isa & Moussa, 1999	Cross sectional	KUW	3 - 5	3433 (51)	NCHS/ CDC	4	3.4	4.5	10	7.8	11.7	**7**
10. Al Qaoud and Parkash, 2009	National surveillance Cross sectional	KUW	3 - 5	2291 (48)	CDC	8	-	-	12	-	-	**7**
11. Al Qaoud et al., 2010	National surveillance Cross sectional	KUW	3 - 5	482 (45)	WHO	42	-	-	58	-	-	**5**
12. Al Refaee et al., 2013	Hospital screening Cross sectional	KUW	<6	361 (54) * 0-10 y	CDC	30	-	-	-	-	-	**5**
13. Elkum et al., 2015	Cross sectional	KUW	6	6574 (40) *6-18y	CDC	13	-	-	25	-	-	**7**
					WHO	14	-	-	20	-	-	
					IOTF	15	-	-	16	-	-	

IOTF, International Obesity Task Force, CDC, Centers of Disease Control, WHO, World Health Organisation, NCHS, National Centre of Health Statistics. KUW: Kuwait

Table 1-9 Characteristics of included studies in Saudi Arabia

Author	Study design	Country (region)	Age (y)	Sample size (n) (% male)	Method	Overweight (%)			Obesity (%)			Quality assessment
						All	Boys	Girls	All	Boys	Girls	
14. Al Hazmi and Warsy, 2002	Cross sectional	KSA	2 - 18	12701 (49)	Cole et al.	-	10.7	12.7	-	6.0	6.7	**7**
		C	2 - 6	-	Cole et al.	-	4.2	9.5	-	11.2	11.6	
		E	2 - 6	-	Cole et al.	-	24.3	16.3	-	34.4	20.5	
		N	2 - 6	-	Cole et al.	-	10	7.9	-	11.4	14.4	
		W	2 - 6	-	Cole et al.	-	7.3	3.6	-	12.0	14.6	
		S	2 - 6	-	Cole et al.	-	3.7	2.6	-	9.8	5.1	
15. Al Hazzaa and Al Rasheedi, 2007	Cross sectional	KSA (JED)	4 – 6	224 (49)	IOTF	-	-	-	11	-	-	**5**
16. Al Dossary et al., 2010	Cross sectional	KSA	2 – 4	1857(56)	CDC	18	-	-	19	-	-	**6**
17. Al Mouzan et al., 2010	Cross sectional	KSA	5 – 6	2943 (51)	WHO	12.4	12.3	12.5	4.6	4.9	4.2	**7**

Table 1-10 Characteristics of included studies in Saudi Arabia, Bahrain and Qatar

Author	Study design	Country (region)	Age (y)	Sample size (n) (% male)	Method	Overweight (%)			Obesity (%)			Quality assessment
						All	Boys	Girls	All	Boys	Girls	
18. Al Mouzan et al., 2012	Multi stage stratified Cross sectional	KSA	2 – 6	2874	CDC	13.4	14.0	12.9	5.9	6.2	5.6	**7**
		C	2 - 6	975 (53)	CDC	15.9	16.6	15.1	7.5	8.4	6.5	
		SW	2 – 6	815 (48)	CDC	8.2	9.5	7.1	2.9	2.8	3.1	
		N	2 – 6	1084 (50)	CDC	16.2	16.1	16.4	7.3	7.4	7.2	
19. Al Raees et al., 2009	Cross sectional	BAH	2 – 6	698 (49)	WHO	-	9.8	10.1	-	7.1	5.9	**7**
					IOTF	-	7.2	6.2	-	3.0	4.2	
20. Bener and Kamal, 2005	Cross sectional	QTR	6 - 9	2140 (50)	IOTF	-	16.3	15.5	-	3.5	2.8	**6**

IOTF, International Obesity Task Force, CDC, Centers of Disease Control, WHO, World Health Organisation, KSA: Saudi Arabia C: Central, E: East, N: North, W: West, S: South, SW: South West, BAH: Bahrain, QTR: Qatar.

Chapter 2 Risk factors of preschool overweight and obesity

'Obesity is caused by a complex web of societal and biological factors that have, in recent decades, exposed our inherent vulnerability to weight gain' – Foresight (2007)

2.1 Aetiology of childhood overweight and obesity

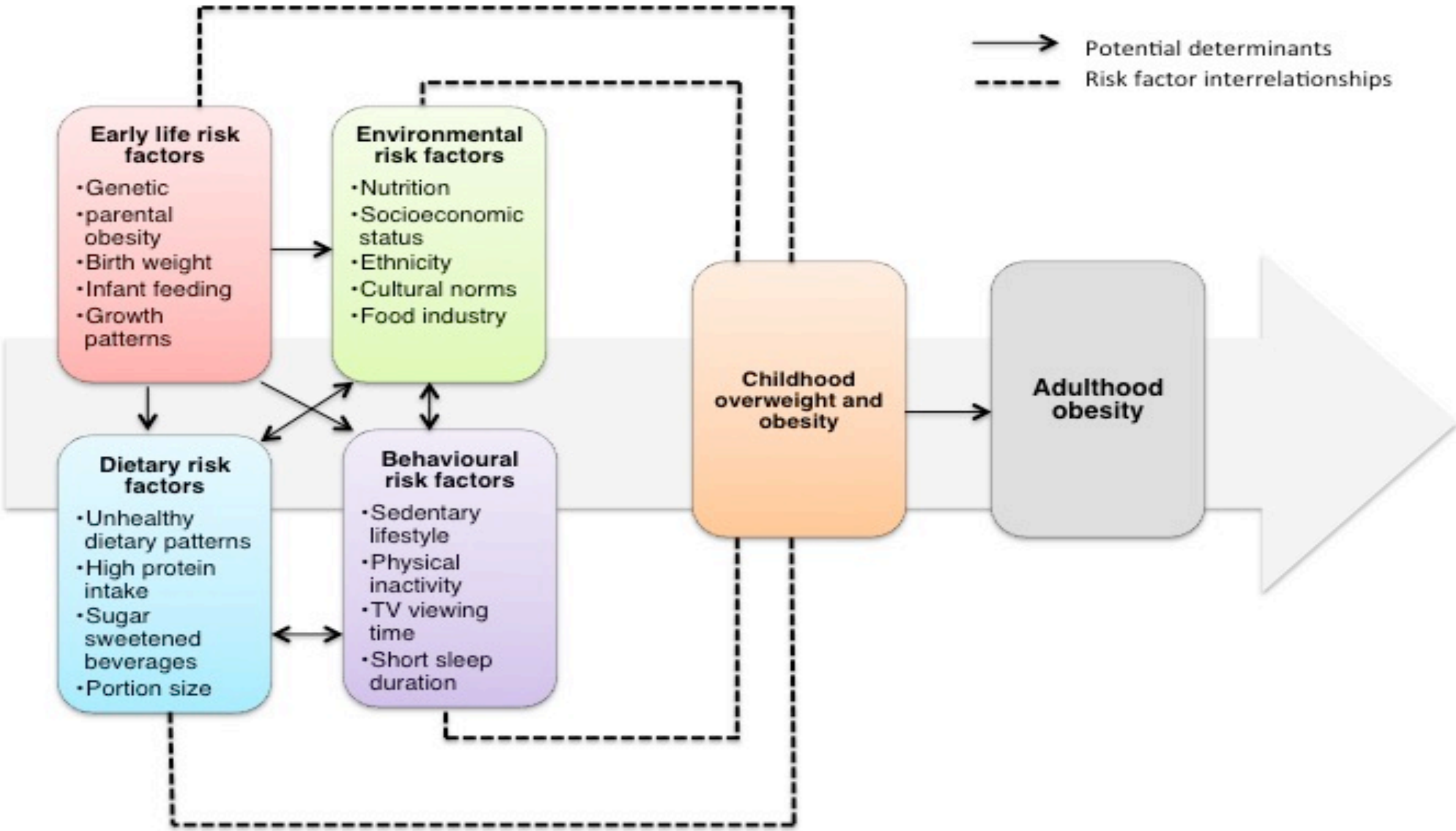
The aetiology of obesity is multifaceted. It is most simply explained by a prolonged period in which energy intake exceeds energy expenditure, leading to weight gain (Reilly et al., 2005). Several potential risk factors have been identified, including: genetic, environmental, developmental, behavioural and dietary factors (Monasta et al., 2010; Woo Baidal et al., 2016)(Figure 2-1). However, because of the complexity of the interrelationships, the mechanism responsible for the development of obesity among children remains unclear.

Many systematic reviews (see, Table 2-1) have summarised evidence of risk factors influencing the development of overweight and obesity starting from early life. Most studies included in these reviews have been carried out in developed countries. Thus, little is known about the influence of these risk factors in developing countries.

Identification of potential modifiable risk factors of preschool obesity is important, in order to develop interventions to prevent obesity. In addition to potentially modifiable risk factors of preschool obesity, some factors are non-modifiable (e.g. genes, parents, ethnicity) or difficult to modify (e.g. socioeconomic status), but also need to be considered in order to target high-risk individuals or populations. Although the focus of this research is to determine risk factors that can be modified through interventions, for completeness, non-modifiable risk factors are also discussed below.

This chapter aims to discuss potential determinants of preschool obesity, focusing on early life, behavioural and environmental risk factors, particularly in the UAE and neighbouring Arab Gulf countries. A major aim of this thesis is to determine for the first time whether the risk factors for preschool obesity seen in Western populations are relevant to the UAE. Another main focus of the current thesis is to identify dietary risk factors of preschool obesity in the UAE, which will be addressed in Chapter 3. This data could help develop possible appropriate interventions to reduce obesity risk among preschool children in the UAE.

Figure 2-1 Potential risk factors and interrelationships



2.2 Non-modifiable risk factors

2.2.1 Genetic influences

Genetic tendencies are a strong determinant of childhood obesity. In family and twin studies, the heritability of obesity has been found to range between 30% and 70% (Alfredo Martinez et al., 2007; Llewellyn et al., 2013). It is commonly accepted that obesity is polygenic, where several genes influence obesity risk by altering behaviour, appetite and energy balance (Wardle, 2005). One of the first genes to be identified, and of the largest effect sizes, is the FTO (fat mass and obesity associated) gene identified by genome-wide association studies (GWAS). This gene has been found to be associated with a high energy intake, a high intake of dietary fat and low levels of satiety in children. However, the association between the FTO gene and BMI shows a small effect size (0.5% of variance of BMI explained) (Frayling et al., 2007; Wang et al., 2012)

A recent meta-analysis of GWAS identified 97 genetic variants associated with BMI, and suggested that only 2.7% of BMI variation can be explained by these genes (Locke, 2015). Hence, each individual gene has only a small effect on BMI, and therefore modifiable environmental risk factors are likely to be particularly important in the prevention of obesity. The high variation of body weight within populations illustrates the propensity of individuals to become overweight or obese in the face of an obesogenic environment, i.e. 'genes load the gun, environment pulls the trigger' (Lobstein et al., 2004). Hence, genes alone cannot explain the obesity epidemic, because, for example, genes have not dramatically changed in the last 20 years, whilst the prevalence of obesity has increased.

Obesity is most likely an intertwined relationship between genes and the 'obesogenic environment', which predisposes susceptible individuals to a positive energy imbalance through the provision of readily accessible energy dense food and technological advancements that reduce physical activity (Swinburn et al., 1999; Styne, 2005).

2.2.2 Parental Obesity

Parental obesity is a strong contributory factor in the development of childhood obesity (Monasta et al., 2010). For example, the risk of a child becoming obese doubles if one parent is overweight or obese, and if both parents are obese, the risk is found to triple (Wardle et al., 2006; Emmett and Jones, 2015). Other than by genetic mechanisms, parents play a role in influencing food choices and behaviour, particularly during the preschool years. The aggregation of adiposity within families could therefore be explained by common environmental exposures rather than genetic predisposition (Toselli et al., 2015). This emphasises the important role of parents at an early age in influencing a healthier lifestyle later in life (Wardle et al., 2001; Fraser, 2013).

2.2.3 Ethnicity

Several studies have documented that certain ethnic groups are at a higher risk of obesity (Saxena et al., 2004; Taylor et al., 2005). The influence of racial/ethnic disparities on obesity has been observed in many countries, including the UK (Karlsen et al., 2014) and the US (Freedman et al., 2006; Skinner and Skelton, 2014). In the UK, paediatric obesity has been found to be highest in black ethnic groups (Ells et al., 2015; Zilanawala et al., 2015). For example, using data on overweight and obesity in 5 year old children from the Millennium Cohort study (UK), Zilanawala et al. (2015) found that the highest risk of obesity in was among Black Caribbean children (OR= 1.7; 95% CI: 1.1 to 2.6) and least risk of obesity was among Pakistani children (OR= 0.06; 95% CI: 0.37 to 0.96) compared to White children, after adjusting for socioeconomic, cultural and maternal BMI (Zilanawala et al., 2015). A higher prevalence of childhood obesity has also been documented amongst children of South Asian origin compared to children of White British origin (Saxena et al., 2004; National Child Measurement Programme, 2015).

The influence of ethnic disparities on obesity risk could be explained by socioeconomic disadvantage, cultural beliefs, behavioural norms and family characteristics. However, because the definition of ethnicity or ‘ethnic group’ may include national identity, religion, language, birth country and culture, this relationship is not always straightforward. Therefore, given that a complex interplay of factors may affect ethnic communities differently, culturally appropriate health promotion interventions are best targeted at high-risk ethnic groups (Falconer et al., 2014; Toselli et al., 2015).

2.2.4 Socioeconomic status

The association between socioeconomic status (SES) and obesity is complex and varies widely between different SES levels (Wang and Lobstein, 2006). In general, the risk of obesity is greatest in low SES groups in developed countries (e.g. USA, UK) (Knai et al., 2012), and in high SES groups in developing countries (e.g. China, Egypt) (Wang, 2001; Stamatakis et al., 2010; Gupta et al., 2012). These differences between low and high-income countries could be explained by differences in access to food, health care services and recreational facilities. For instance, in China, richer people have greater access to meat and other energy-dense foods compared to those who are less affluent (Ge et al., 1996), while in the US, higher SES groups consume more fruits and vegetables compared to lower SES groups (Wang, 2001).

However, the association between obesity risk and socioeconomic status is not consistent. For instance, a systematic review by Shrewsbury and Wardle (2008) assessed the association between SES and obesity risk in children in the UK. From forty-five studies included in the review, 19 studies (42%) found an inverse association of SES with adiposity, 14 studies (31%) reported a mixture of no association and inverse associations, whereas 12 studies (27%) found no association (Shrewsbury and Wardle, 2008). However, overall, the association between low SES and risk of overweight and obesity is generally accepted.

The lack of agreement between studies linking social class with obesity therefore indicates a need to understand the underlying mechanisms by which such an association may manifest.

A recent systematic review by Mech et al. (2016) found that different SES groups may have different risk factors and protective factors for obesity. For example, among low SES families, parental obesity and maternal depressive symptoms were found to increase the risk of childhood obesity; whereas in high SES groups, long maternal work hours and permissive parenting styles were identified as risk factors for obesity (Mech et al., 2016). These findings suggest that future interventions should be tailored to address specific risk factors for obesity in different socioeconomic groups.

2.3 Modifiable risk factors

2.3.1 Early life risk factors for later obesity

Early life factors during infancy and childhood have been proposed to influence the long-term development of obesity. These include infant birth weight, infant feeding practices and growth patterns (Weng et al., 2012; Lifschitz, 2015). However, most of the data are based on observational studies and causality has not been established. Nevertheless, these factors raise the possibility of preventing obesity in the early years, and therefore this area has become an active area of research.

2.3.1.1 Birth weight

Numerous systematic reviews have found a positive linear association between mean birth weight and subsequent obesity in childhood and later life (see, Table 2-1). These systematic reviews have also reported a significant and strong positive association between high birth weight (>4kg) and childhood obesity (Baird et al., 2005; Hawkins et al., 2009; Monasta et al., 2010). For example, a systematic review by Yu et al. (2011), found that a high birth weight (>4kg) was associated with a two-fold risk of obesity (OR= 2.07; 95% CI 1.9 to 2.24) compared with birth weight <4kg. On the other hand, low birth weight (<2.5kg) was associated with a decreased risk of obesity compared with a birth weight >2.5kg (OR= 0.61; 95%: CI 0.46 to 0.80) (Yu et al., 2011).

A more recent systematic review by Woo Baidal and colleagues (2016) similarly showed a consistent association between high birth weight and later childhood overweight and obesity in 24 out of 28 studies. Hence, high birth weight is considered a mediator between antenatal factors such as maternal nutrition and later obesity risks. However, it is unclear whether the high birth weight is due to adiposity or a combination of lean and fat mass (Wells et al., 2007; Woo Baidal et al., 2016). For example, a positive association between birth weight and later obesity could represent an association between birth weight and fat-free mass rather than fat mass, as shown by Singhal et al. (2003). In this study, an increase of 1 standard deviation in birth weight was associated with 2%-3% (0.9-1.4kg) greater fat-free mass, but not with fat mass in adolescents (Singhal et al., 2003).

Intervention studies that aimed to reduce the risk of maternal obesity and/or gestational diabetes have not consistently shown associations between antenatal nutrition and offspring birth weight. For example, findings from the largest intervention trials (ROLO (Walsh et al., 2012), LIMIT (Dodd et al., 2014), UPBEAT (Poston et al., 2015) have shown few effects on birth weight or on the offspring's later obesity risk, although the LIMIT trial showed that fewer babies were born large for gestational age in the intervention group (Dodd et al., 2014), the association between antenatal factors and offspring obesity remains unproven. However, recent follow-up data of infants at 6 months from the UPEAT intervention trial (targeting maternal diet and physical activity) found that subscapular skinfold thickness z-score was 0.26 (95% CI: –0.49 to –0.02; P=0.03) lower in the intervention group compared to controls, suggesting that a maternal behavioural intervention focused on improving maternal diet and reducing gestational weight gain during the antenatal period could potentially reduce infant adiposity (Patel et al., 2017).

2.3.1.2 Breastfeeding and obesity risk

Breastfeeding is recognised internationally as the optimal way to feed an infant. The World Health Organisation (WHO) has recommended exclusive breastfeeding up to 6 months, and continued breastfeeding up to 2 years as ideal for growth and development (World Health Organisation, 2003b).

While there is extensive evidence for the health benefits associated with exclusive breastfeeding, this practice is often not followed for the recommended time in either developed countries or developing countries (Lauer et al., 2004; Ip et al., 2007; Victora et al., 2016). A recent review by Victoria et al. (2016) reported that, although more than 80% of infants worldwide receive breast milk at birth (Victora et al., 2016), the duration of exclusive breastfeeding declines by six months, and varies widely between countries. For example, in the UK, by 6 months, 1% of infants are exclusively breastfed (McAndrew et al., 2012), whereas in developing countries, approximately 39% are exclusively breastfed (Cai et al., 2012).

Breastfeeding is protective against several illnesses, including infectious diseases, immunological disorders, inflammatory diseases, and confers neurological and psychological development, probably a result of bioactive and immune-protective properties found in breast milk (Stettler, 2007; Horta and Victora, 2013). However, while the short-term benefits are well recognised, the long-term benefits of breastfeeding remain controversial. Whether breastfeeding confers long-term benefits for health (e.g. obesity risk) has been extensively researched in systematic reviews and meta-analyses (see, Table 2-1).

These reviews suggest that breastfed infants have a lower risk of obesity, diabetes (Horta and Victora, 2013) and high blood pressure (Martin et al., 2005) in adulthood. With regard to obesity, two systematic reviews that included 28 studies (~300 000 subjects) and 36 studies (~355 000 subjects) found that breastfeeding is associated with a decreased risk in obesity and lower BMI in later life. However, after adjusting for confounders, the association between breastfeeding and obesity and mean BMI was reduced (Owen et al., 2005a; Owen et al., 2005b).

The duration of exclusive breastfeeding required to confer protection against obesity is also unclear. In one meta-analysis of intervention studies, promoting a longer duration of breastfeeding was not protective against obesity (Kramer and Kakuma, 2002; Giugliani et al., 2015). However, a recent meta-analysis for the

WHO suggested that a longer duration of breastfeeding reduced the risk of overweight and obesity by 26% (95% CI: 22 to 30) (Horta et al., 2015). This latter study supports earlier findings of a dose-response effect of breastfeeding on the risk of obesity, by which each additional month of breastfeeding reduced the risk of obesity by 4% (Harder et al., 2005). Thus, promoting a longer duration of breastfeeding could confer long-term health benefits.

However, the association between breastfeeding and obesity risk remains unproven due to the observational study design and the possible impact of confounding factors (e.g. maternal age, educational level, maternal smoking, lifestyle habits, maternal body mass index, ethnicity, socioeconomic level and infant health) that can also influence obesity risk. Moreover, inconsistent evidence presented in systematic reviews could be a due to (i) the heterogeneity of studies, which have a wide range of exposures and different outcomes; (ii) different definitions of exclusivity or duration of breastfeeding and (iii) various definitions of overweight and obesity (Stettler, 2007). Furthermore, as it is not ethically possible to randomise mothers to infant feeding practices (e.g. breast milk or formula milk), a causal relationship between breastfeeding and obesity cannot be established.

2.3.1.3 Mechanisms behind the long-term effects of breastfeeding on obesity risk

Several mechanisms have been suggested to explain the benefit of breastfeeding against later obesity. These include residual confounding factors, biological factors (e.g. differences in the nutritional composition of breast milk and formula milk) and behavioural mechanisms. Residual confounding factors include, for example, the possibility that families that are health conscious may be more likely to breastfeed (Stettler, 2007). On the other hand, the low rate of breastfeeding among low-income families who have behaviours predisposing them to obesity could partly explain their high risk of obesity (Relton et al., 2016).

Behavioural factors that could explain the association between breastfeeding and obesity include differences in parental and infant feeding styles between breastfed and formula fed infants that influence satiety responsiveness in early infancy and so could influence obesity risk in later life. For example, breastfed infants are better able to self-regulate their energy intake in response to internal hunger and satiety cues, compared to those who are formula fed (Koletzko, 2006; Ong et al., 2006; Kelishadi and Farajian, 2014).

Lastly, differences in the nutritional composition of human milk and formula milk may influence obesity risk. These include differences in energy and macronutrient content, bioactive components and hormones (Marseglia et al., 2015), which could influence immune regulation, metabolic responses and adipogenesis (Latuga et al., 2014; Victora et al., 2016). In addition, the lower protein content of breast milk (approximately 70% less than formula milk) has been hypothesised to explain differences in growth patterns during infancy (Dewey, 2003; Koletzko, 2006) and ultimately differences in the risk of obesity between breastfed and formula fed infants.

2.3.1.4 Growth patterns

One of the major differences between breastfed and formula fed infants is weight gain velocity. The ‘Growth Acceleration Hypothesis’ described by Singhal and Lucas (2004) postulated that the slower growth pattern of breastfed infants compared with formula fed could explain the lower risk of obesity and cardiovascular diseases (Singhal and Lucas, 2004).

This concept is supported by several systematic reviews (see, Table 2-1), which have shown that rapid growth during the first two years of life is associated with a two to three-fold increased risk of obesity in childhood (Ong and Loos, 2006; Koletzko et al., 2009; Woo Baidal et al., 2016). Formula fed infants grow faster than those who are breastfed, for reasons that are poorly understood. One proposed mechanism is the higher protein content of formula compared to breast milk, which promotes rapid weight gain in formula fed infants by mediating the secretion of insulin and insulin-like growth factor 1 (IGF-1). These growth factors enhance fat deposition and weight gain (Adair, 2014; Koletzko et al., 2016).

Findings from a large multicentre European double-blind intervention support the impact of protein on obesity risk. This study randomised infants to a standard (1.77 and 2.2g protein/100kcal) or high protein content (2.9 and 4.4g protein/100kcal) infant formula during the first year of life, and found that infants fed a higher protein formula gained more weight and were heavier at 2 years of age (Koletzko et al., 2009). At a longer-term follow-up at 6 years of age, the risk of becoming obese was almost twice as higher in the high protein group compared to those receiving a standard (OR= 2.43; 95% CI: 1.12 to 5.27; p=0.024) (Weber et al., 2014; Koletzko et al., 2016). These findings suggest that a lower protein intake in infancy could help prevent fast growth and reduce the risk of obesity in later life (Singhal and Lucas, 2004).

2.3.1.5 Complementary feeding and obesity risk

Complementary feeding is defined as the introduction of food or liquid (other than water) to the hitherto exclusively breastfed infant. Complementary feeding is essential to meet the nutritional requirements of infants, when breast and/or formula milk are no longer sufficient (Kramer, 2010). The complementary feeding period is a critical window where nutrient demand is high, food preferences are established and eating habits are shaped (Cooke et al., 2004; Grote et al., 2012); (Coulthard et al., 2010).

Early introduction of food, before 6 months of age, is discouraged by the WHO recommendations (World Health Organisation, 2003a), as it reduces the recommended duration of exclusive breastfeeding. Early complementary feeding has also been suggested as a risk factor for childhood obesity (see, Table 2-1) (Zheng et al., 2015), although evidence is equivocal and conflicting. Previous systematic reviews found no clear association between the age of solid introduction and obesity risk (Moorcroft et al., 2011; Pearce et al., 2013).

However, some evidence suggests that early introduction (before 4 months of age) may increase the risk of obesity (Pearce et al., 2013). More recently, pooled results from a meta-analysis of ten prospective cohort studies (63,605 participants) showed that introducing complementary food before 4 months compared to 4 to 6 months increased the risk of overweight (Relative Risk (RR) for overweight, 1.18; 95%CI, 1.06, 1.14), and obesity (RR for obesity, 1.33; 95%CI, 0.90, 1.13) during childhood, whereas delaying complementary foods until after 6 months showed no association with overweight and obesity (Wang et al., 2016). The relationship between the timing of introducing solids and obesity remains unproven, mainly because of the observational design of studies and the lack of a clear mechanism. Differences between studies could be explained by heterogeneity in study design (e.g. different age of complementary feeding and type of measured outcomes (e.g. BMI), and the inability to distinguish whether early introduction of solids induces early cessation of breastfeeding (Yan et al., 2014; Grube et al., 2015) or by the influence of socioeconomic confounding factors. For example, many studies have reported that low-income families may start complementary feeding earlier than the recommended period of 6 months.

Proposed mechanisms by which early complementary feeding may increase the risk of obesity include behavioural and nutritional influences. Parental feeding style and type of food introduced have also been suggested to influence obesity risk (Kramer, 2010). For instance, infants introduced to complementary food with the baby-led method (infants that feed themselves using finger food) may be better able to regulate food intake and show greater preference for healthier foods compared to those fed traditionally (Townsend and Pitchford, 2012). However, only one study has found this, and larger randomised controlled trials are needed.

The amount and type of foods offered during complementary feeding can also influence the later risk of obesity (Ong et al., 2006). For example, higher protein intake during complementary feeding and the toddler years is associated with a higher BMI later in childhood. However, there is limited evidence as to the extent to which protein intake between 4 and 12 months is associated with obesity risk (Günther et al., 2007; Pearce and Langley-Evans, 2013).

2.3.2 Behavioural factors

In contrast to early life factors, which have effects later in childhood, clearly, obesity is also likely to be strongly influenced by lifestyle behaviours. These include physical activity, sedentary behaviours, sleep duration and dietary behaviours (see, Table 2-1). The effects of dietary risk factors are a key focus of this research and hence will be considered in a separate chapter (see, Chapter 3).

2.3.2.1 Physical activity and sedentary behaviours

Physical activity not only plays an important role in the prevention of overweight and obesity in childhood, but also is also essential for the development of musculoskeletal tissues (Gunter et al., 2012), motor skills (Bellows et al., 2013) and cognitive function (Sibley and Etnier, 2003). Current global guidelines recommend at least 60 minutes of moderate-vigorous physical activity per day (World Health Organisation, 2011). However, nearly 50% of preschool children fail to meet these recommendations (Chaparro et al., 2014), and considerable evidence suggests that physical activity levels have declined during the past 20 years (Tucker, 2008; Timmons et al., 2012).

Physical activity during childhood may be particularly important because it is associated with physical activity behaviours in later adulthood (Pate et al., 1996). Therefore, promotion of physical activity in preschool children could help instil healthy habits from a young age (Tucker, 2008).

Low physical activity is suggested to be a risk factor for childhood obesity (Monasta et al., 2010), although the data are conflicting. For example, several studies have shown that obese children are less physically active compared to non-obese children (Trost et al., 2001; Brage et al., 2004; Kunin-Batson et al., 2015). One systematic review of 13 prospective studies among preschool children reported a strong inverse association between total physical activity and overweight in later childhood (<18 years) (te Velde et al., 2012). However, this was not consistent with another systematic review, which showed no consistent relationship between physical activity and obesity (BMI) among preschool children (Hinkley et al., 2008). Hence, the role of physical activity in the prevention of overweight and obesity remains controversial, although most health care professionals would regard physical activity as one of many risk factors for obesity.

The role of physical activity interventions, as opposed to physical activity levels, in obesity prevention is also unclear. For instance, a systematic review by Hesketh and Campbell (2010) found that although interventions increased physical activity among preschool children (Reilly et al., 2006), this did not reduce obesity risk. Thus, the efficacy of these interventions in overweight prevention needs to be further studied.

The relationship between obesity and sedentary behaviour, as opposed to physical activity, is also inconsistent (Abbott and Davies, 2004; Cliff et al., 2016; van Ekris et al., 2016). Some studies report that TV viewing time is associated with greater adiposity (Biddle et al., 2004). However, a recent systematic review and meta-analysis of prospective studies found no association between TV viewing or computer use in childhood and BMI during youth or adulthood (van Ekris et al., 2016).

Disagreements between studies could be due to methodological differences in measuring physical activity, for example using objective (e.g. accelerometers)[10] or subjective measures (e.g. questionnaires) and the inaccuracy of parents' reporting of TV viewing time (Sijtsma et al., 2015). Also, the observational nature of these studies cannot define causality and it is unclear whether obese children are less physically active, or low physical activity leads to weight gain.

Despite the conflicting evidence, overall it is widely accepted that sedentary behaviour is detrimental and a major risk factor of childhood obesity. Reducing sedentary behaviour is accepted as part of the childhood obesity strategy (Ending

[10] Accelerometers provide objective and valid estimates of physical activity and sedentary time (Pate et al., 2006).

Childhood Obesity commissioned by the WHO), to promote physical activity, provide guidance on appropriate use of screen-based entertainment and ensure adequate facilities are available at both school premises and public spaces (World Health Organisation, 2016).

2.3.2.2 Sleep duration

The association between short sleep duration[11] and overweight and obesity appears to be consistent and has been observed in several populations (Sekine et al., 2002; Reilly et al., 2005; Bell and Zimmerman, 2010; Thind et al., 2015). A meta-analysis of 12 cross-sectional studies showed that short sleep duration was associated with the development of overweight and obesity in young children (Cappuccio et al., 2008).

Similarly, another meta-analysis of 17 observational studies from diverse populations found that children sleeping less than the recommended 11 hours of night sleep (categorised as short sleep[12]) had a significantly higher risk of overweight/obesity (OR: 1.92; 95% CI: 1.15 to 3.20) (Chen et al., 2008; Taveras et al., 2008; Scharf and DeBoer, 2015).

Possible mechanisms for the association between short sleep duration and obesity risk include a lower energy expenditure and higher energy intake in those sleeping less (due to tiredness) (Bell and Zimmerman, 2010; Fisher et al., 2014). Findings from the prospective UK Gemini twin cohort study found that 16-month-old children who slept less than 10 hours consumed approximately 120 more calories (at night) at 21 months compared to those who slept more than 13 hours (McDonald et al., 2014). Short sleep may also influence hypothalamic mechanisms that regulate metabolism and bodyweight through the hormones

[11] Children under the age of 5 are recommended more than 11 hours of night sleep (Reilly et al., 2005; Sekine et al., 2002).
[12] Cut-offs used in Chen et al. (2008) review to define/classify shorter sleep (<9 hrs), much shorter (9-10 hrs), shorter (10-11 hrs).

leptin and ghrelin[13] (Spiegel et al., 2004), which could, in turn, influence appetite and energy balance (Patel and Hu, 2008).

Overall, most research investigating risk factors for obesity has focused on high-income countries, and despite the rise of obesity in the Arabian Gulf region, few such studies have addressed this issue in this region. Although, there is widespread agreement that reduced physical activity, increased sedentary behaviours and poor diets increase obesity risk in preschool children living in transitional countries, there is little evidence in children from the Arabian Gulf. Therefore, the next section systematically reviews risk factors for the development of preschool obesity, focusing on both non-modifiable (ethnicity, socioeconomic status) and modifiable risk factors (developmental, behavioural, dietary) in the UAE and neighbouring Arab Gulf countries.

[13] Hunger and appetite increase with low leptin and high ghrelin levels.

Table 2-1 Summary of systematic reviews on risk factors of preschool obesity

Risk factor	Evidence	Findings
High birth weight	Martins and Carvalho, 2006	Positive association between birth weight and obesity in infancy and childhood found in 14/20 studies. Negative association found in 3/20 studies.
	Woo Baidal et al., 2016	High birth weight associated with later childhood obesity in 24 out of 28 studies
	Schellong et al., 2012	Low birth weight (<2500g) was found to be associated with a decreased risk of overweight (OR: 0.67; 95% CI: 0.59, 0.76). High birth weight (>4000g) was associated with an increased risk of overweight (OR: 1.66; 95% CI: 1.55, 1.77).
	Weng et al., 2012	6/7 found a significant and strong independent association between childhood overweight and high infant birth weight (OR: 1.47; 95% CI: 1.26, 1.73).
	Yu et al., 2011	High birth weight (>4000g) was associated with increased risk of obesity compared with subjects with birth weight (<4000g) (OR: 2.07; 95% CI: 1.91, 2.24). Low birth weight was significantly associated with a decreased risk of obesity compared with birth weight (>2500g) (OR: 0.61; 95% CI: 0.46, 0.80).
Fast growth and infant weight gain	Woo Baidal et al., 2016	Fast growth/weight gain consistently associated with later childhood overweight in 48 studies.
	Weng et al., 2012	Six studies found a significant and strong independent association between rapid weight gain during the first year of life and childhood overweight
	Monterio and Victoria, 2005	13/15 studies found a significant association between early rapid growth and later overweight or obesity
	Barid et al., 2005	7/10 studies found that rapid growth in infancy was significantly associated with obesity at ages from 4.5 – 20 years.

Table continued on next pages

Risk factor	Evidence	Findings
	Patro-Golab et al., 2016	A consistent association of breastfeeding with a modest reduction in the risk of overweight and obesity in childhood and adulthood (OR: 0.87; 95% CI: 0.76, 0.99)
	Horta et al., 2015	Breastfeeding lowered the risk of overweight and obesity by 13%(OR: 0.74; 95% CI: 0.70 – 0.78)
	Yan et al., 2014	Breastfeeding was associated with a reduced risk of obesity in children (OR: 0.78; 95% CI: 0.74, 0.81).
	Horta and Victoria, 2013	Update of Horta et al. (2007) review: observed an association between breastfeeding and lower prevalence of overweight/obesity in later life. Meta-analysis of high quality studies suggests a small reduction of 10% in the prevalence of overweight and obesity in children exposed to longer duration of breastfeeding.
Breastfeeding	Weng et al., 2012	15% decrease in the odds of childhood overweight when comparing breastfed and non-breastfed infants. (OR: 0.85; 95% CI: 0.74, 0.99).
	Horta et al., 2007	Breastfed infants are less likely to be classified as overweight and/or obese.
	Plageman and Harder, 2005	Breastfeeding associated with a decreased risk of overweight and obesity in children later in life
	Owen et al., 2005a	Breastfeeding associated with a lower mean BMI than formula feeding. No association found following adjustment for confounders.
	Owen et al., 2005b	Breastfeeding associated with a reduced risk of obesity compared with formula feeding, Association was attenuated following combined adjustment for confounders.
	Harder et al., 2005	Duration of breastfeeding inversely associated with the risk of overweight: 4% decrease in risk per 1 month of breastfeeding 4% decrease in risk OR 0.96 per month of BF; 95% CI: 0.94, 0.98).
	Arenz et al., 2004	Breastfeeding has a small but consistent protective effect against obesity A dose-dependent effect of breastfeeding duration demonstrated in 4/8 studies.

Risk factor	Evidence	Findings
Early introduction of solids (Complementary feeding)	Woo Baidal et al., 2016	8 studies found evidence of an association between introduction of solids before 4 months of age and obesity in later childhood, overall evidence is inconsistent
	Wang et al., 2016	Introduction of solids before 4 months compared to 4 to 6 months was associated with an increased risk of overweight (RR, 1.18; 95% CI, 1.06-1.31) or obesity (RR, 1.33; 95% CI, 1.07-1.64) during childhood. No significant relationship found when delaying solids after 6 months for overweight (RR, 1.01; 95% CI: 9.0, 1.13) and obesity (RR, 1.02; 95% CI: 0.91,1.14).
	Grote and Theurich, 2014	Childhood obesity is not linked to any specific types of foods or food groups during the complementary feeding period.
	Pearce et al., 2013	5/21 studies found introducing solids before 3 months (2 studies), 4 months (2 studies) or 20 weeks (1 study) was associated with a higher BMI in childhood. 1 study reported an increase in body fat percentage among those introduced solids before 15 weeks. Overall, no clear association however early introduction may increase the risk of childhood overweight.
	Pearce and Langley-Evans, 2013	High-energy intake during complementary feeding was associated with higher BMI during childhood. Some association was found between high protein intakes at 2-12 months of age and higher BMI OR body fatness in childhood.
Diet	Patro-golab et al., 2016	No consistent evidence of an association between sugar sweetened beverages or energy intake in early childhood with later overweight and obesity, but some indication of an association between protein intake and later overweight and obesity.
	Malik et al., 2013	Meta-analysis of 32 articles found that one daily serving increment of SSBs was associated with (OR: 0.06; 95% CI: 0.02, 0.10) and (OR: 0.05; 95% CI: 0.03, 0.07)-unit increase in BMI in children in random- and fixed effects models.
	te velde et al., 2012	Insufficient evidence for an association between dietary intake or dietary behaviour and overweight
	Malik et al., 2006	Findings from cross-sectional studies and prospective cohort studies show a positive association between greater intakes of SSBs and weight gain and obesity in both children and adults.

Risk factor	Evidence	Finding
Physical activity and Sedentary behaviour	Cliff et al., 2016	Meta-analysis provided weak evidence for a cross-sectional association between overall sedentary time and adiposity (r = 0.07; 95% CI: 0.00, 0.13) (p = 0.024). No association reported in longitudinal studies.
	Van Ekris et al., 2016	Findings from meta-analysis of prospective studies found inconclusive evidence for an association between television viewing and obesity (each additional hour of TV viewing (β = 0.01; 95% CI: -0.002, 0.02) or computer use (β = 0.00; 95% CI: -0.004, 0.01) per day was not significantly associated with BMI at follow-up
	te Velde et al.,2012	Strong evidence for an inverse association between physical activity and overweight. Moderate evidence was observed for a positive association between television viewing and overweight
	Hinkley et al., 2010	No consistent association found between sedentary behaviour and BMI among preschool children
	Hinkley et al., 2008	No consistent relationship was found between physical activity and BMI among preschool children
Sleep Duration	Wu et al., 2016	Meta-analysis provided evidence that short sleep duration is association with a significantly increased risk of obesity in children (OR: 1.71; 95% CI: 1.36, 2.14).
	Ruan et al., 2015	25 eligible studies found that compared with children having the longest sleep duration (~12/2hrs), children with the shortest sleep (~10hrs) were 76% more likely to be overweight /obese (OR: 1.76; 95% CI: 1.39, 2.23). With every 1-hour per day increase in sleep duration the risk of overweight and obesity was reduced by 21% (OR: 0.79; 95% CI: 0.70, 0.89).
	Fatima et al., 2015	Review of 22 longitudinal reviews found an inverse association between sleep duration and BMI (OR: 1.27; 95% CI: 1.05, 1.53). Meta-analysis of 11 studies found that short sleep doubled the risk of being overweight and obese compared to long sleep duration (OR: 1.46; 95% CI: 1.24, 1.72).
	Patel and Hu., 2008	13 studies consistently found that short sleep duration associated with weight gain.
	Cappuccio et al., 2008	Meta-analysis findings show a consistent increased risk of obesity among short sleepers in children (OR: 1.89; 95% CI: 1.46, 1.68).
	Chen et al., 2008	Children with shorter sleep duration have a higher risk of overweight or obesity compared with children having longer sleep duration (OR: 1.58; 95% CI: 1.26 – 1.98).
Socioeconomic status/ethnicity	Shrewsbury and Wardle, 2008	SES was inversely associated with adiposity in 19/45 (42%) studies; there was no association in 12/45 (27%) studies. With parental education as a SES indicator, inverse association with adiposity were found in 15/20 (75%) studies
	Wang and Beydoun, 2007	Low socioeconomic status and minority groups are disproportionately affected at all ages in the US.
	Parsons et al., 1999	A strong consistent relationship between low socioeconomic status in early life and increased fatness in adulthood.

2.4 Risk factors associated with obesity in preschool children in the UAE and neighbouring countries: a systematic review

In the United Arab Emirates (UAE) and neighbouring GCC (Gulf Corporation Council) countries, the prevalence of obesity among preschool children is high and rising, as described in the systematic review carried out in (see section 1.12). Although it is well recognised that obesity is a public health problem among Arab Gulf countries, a limited number of studies have investigated determinants of preschool obesity in this region. Some studies have provided insights about the likely contributors of overweight and obesity. However, the main determinants of preschool obesity in the GCC are not well described. For instance, several researchers have suggested that the nutrition transition (see section 1.10) has influenced the rising prevalence of overweight and obesity in Arab Gulf countries. However, individual studies have provided insufficient evidence to inform interventions for the prevention or treatment of obesity in preschool children. Although it has been argued that the dramatic rise in obesity is a result of increased consumption of energy dense foods, and reduced physical activity following the nutrition transition (Musaiger and Al-Hazzaa, 2012), it is still unclear to what extent the nutrition transition has influenced obesity risk in this region. The aim of this systematic review is to summarise evidence on risk factors associated with preschool overweight and obesity in the UAE and neighbouring GCC countries.

2.4.1 Methods

2.4.1.1 Search strategy

A systematic search of the electronic databases PubMed, MEDLINE and EMBASE was carried out to identify all relevant studies investigating factors associated with preschool obesity between January 1980 and November 2016, to include the latest published studies. Studies that measured risk factors (developmental, social, behavioural, and dietary) associated with overweight and obesity among preschool children were included.

The search strategy was developed using the Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) guidelines (Liberati et al., 2009). A combination of search terms was used that included exposures (aetiology, risk factor, determinants, causes, dietary intake, sedentary behaviour, physical activity, breastfeeding, birth weight, infant feeding, complementary feeding) and measures of overweight and obesity (body mass index (BMI), adiposity, body fat percentage), age group (preschool, children, childhood, toddler, kindergarten, child) and study population (UAE, Saudi Arabia, Bahrain, Qatar, Oman and Kuwait). An example search strategy can be found in **Appendix C**. Reference lists of included studies were also hand searched and experts were consulted to identify studies omitted by the database search.

2.4.1.2 Study selection

The systematic review was carried out using procedures described in the Cochrane Handbook of Systematic Reviews (Higgins and Green, 2011). Prospective and cross-sectional studies investigating associations between risk factors and preschool obesity risk were included.

Inclusion and exclusion criteria

Abstracts were screened and studies that met the inclusion criteria described in Table 2-2 were included for full-text review.

Table 2-2 Inclusion and Exclusion criteria

Inclusion criteria
Full-text English and Arabic language articles
Definition of overweight and obesity according to any growth reference
Study included preschool children aged between 2 and 6 years of age
Defined risk factors measured subjectively or objectively
Prospective and cross-sectional studies
Exclusion criteria
Studies that did not report risk factors
Included children outside the age range

2.4.1.3 Data extraction

Titles and abstracts of articles were assessed for compliance with the inclusion criteria. A data extraction sheet based on the Cochrane Consumers and

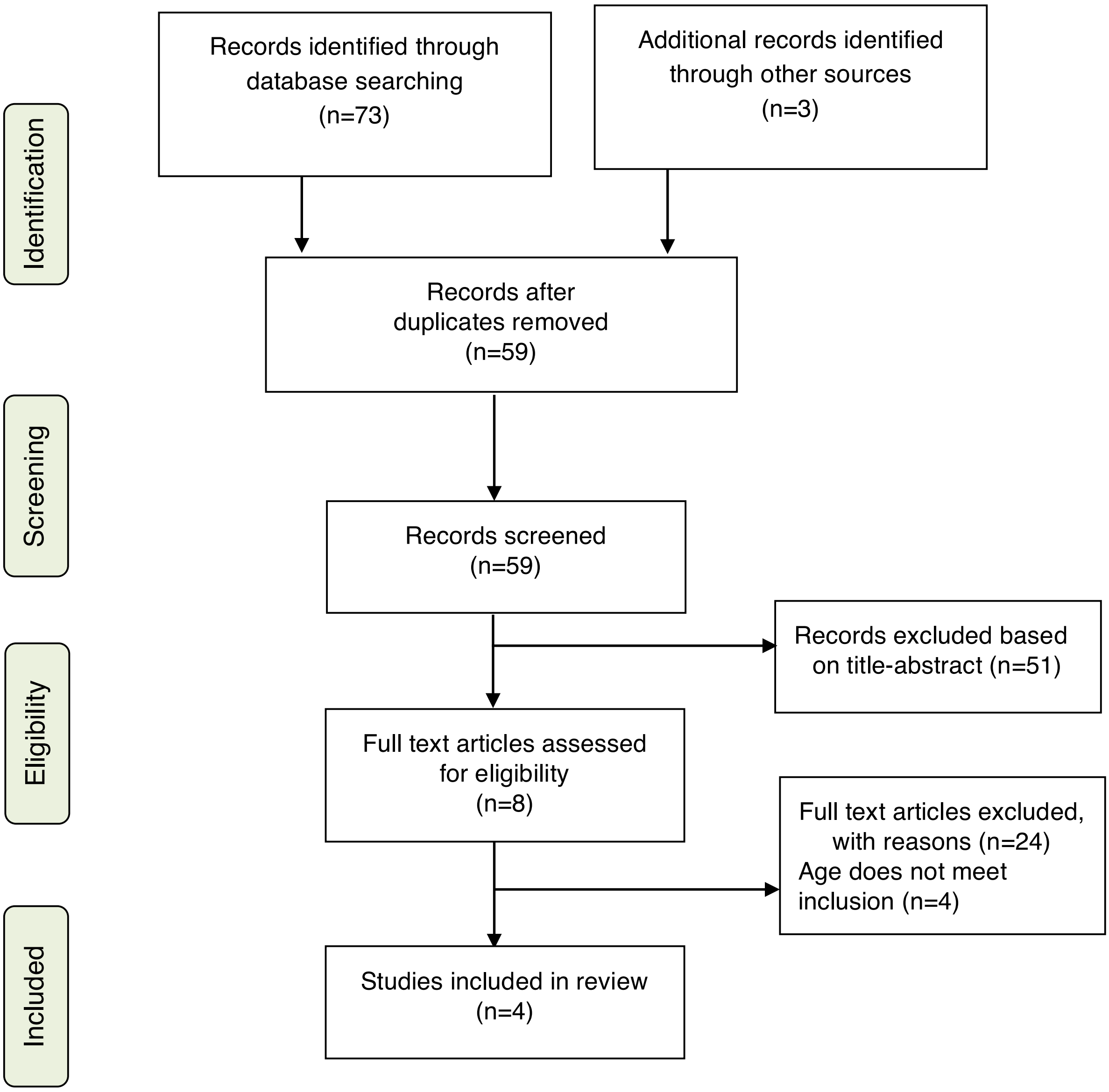
Communications Review Group's template was developed and refined to suit the research question (Higgins and Green, 2011)(**Appendix B**). Where abstracts did not provide sufficient information, full texts were reviewed for screening purposes.

Data were extracted from each study including: (i) characteristics of study participants; (ii) exposures (Including social, developmental, behavioural, and dietary risk factors); (iii) outcome measures (including definition of obesity and assessment methods used); (iv) associations between exposures (risk factors) and outcome (overweight/obesity).

2.4.1.4 Quality assessment

The methodological quality of studies included in the current review was assessed using the Downs and Black checklist, designed to assess bias in both randomised and non-randomised studies (Downs and Black, 1998). The checklist was adapted to include aspects of particular relevance to studies investigating risk factors of preschool obesity. Two reviewers independently scored the studies against the 28-item checklist, which included questions regarding study reporting, external validity, internal validity (bias and confounding) and statistical power (**Appendix D)**. A maximum score of 23 was possible from the questions included in the checklist. Two reviewers discussed discrepancies to achieve agreement. Based on quality index ratings of previous studies, a score equal to or greater than 20 was interpreted as good, 12-19 was of moderate quality, and a score below 12 was considered poor. The final assessment of bias was based on this score and consensus between the two reviewers (myself and Dr. Julie Lanigan).

Figure 2-2 Results of Search Strategy



2.4.2 Results

2.4.2.1 Study characteristics

Study characteristics are presented in Tables 2-3 to 2-5, and include name of first author, year of publication, study participants and design, exposures, assessment methods, definition and measurement of obesity, statistical methods and results. Two reviewers completed data extraction, reporting and interpretation (myself and Dr Julie Lanigan).

Seventy-three articles were identified using the search strategy in **Appendix C**. Screening of abstracts and reference lists identified eight potentially relevant articles. Four studies met the inclusion criteria (Figure 2-2). The main reasons for exclusion were: (i) the age group studied did not include children in the age range set or (ii) studies did not evaluate relationships of risk factors with outcomes.

The current review included 6,375 preschool children aged between 2 and 6 years old. The studies included were from three GCC countries: two from Kuwait and one each from Saudi Arabia and Bahrain. No studies were found in the United Arab Emirates, Oman or Qatar. All studies were cross-sectional except Alawi et al. (2013), who reported retrospective data (Al Alawi et al., 2013).

Each study used a different growth reference to define overweight and obesity, al-Isa and Moussa (1999) used the CDC/NCHS reference alone, Alawi et al. (2013) used the CDC and WHO/NCHS combined, Al Qaoud and Parkash (2009) used CDC only and Al Hazza and Al Rasheedi (2007) used fat-mass index (fat-mass/height^2). Prevalence of overweight and obesity in the GCC was not the focus of this review, and has been covered in Chapter 1, section 1.12.

2.4.2.2 Quality assessment

With respect to methodological quality, studies were of moderate/poor quality (mean index was 11, ranging between 8-16). Two were considered moderate (al-Isa and Moussa, 1999; Al-Qaoud and Prakash, 2009) and two were considered poor (Al-Hazzaa and Al-Rasheedi, 2007; Alawi et al., 2013). These studies scored poorly on items relating to statistical reporting. However, all studies scored well on questions related to reporting of study objectives, outcomes and exposures (see, Tables 2-3 to 2-5).

2.4.2.3 Risk factors of overweight and obesity

2.4.2.3.1 Socioeconomic and urban/rural differences

Associations between SES and overweight and obesity were evaluated in one study. The SES score was based on parental education and occupation, family income, area of residence and number of servants (stay-in domestic helpers). Al Isa and Moussa (1999) found that children living in medium SES families had a lower risk of overweight and obesity compared to those living in lower SES (adjusted OR= 1.51; 95% CI: 1.02 to 2.23; p<0.001). Moreover, the same study found that the risk of overweight and obesity was lower in mostly rural area compared to the capital (urban) (adjusted OR=0.32; 95% CI: 0.19 to 0.54; p<0.001). In addition, a household that employed more than three domestic helpers was associated with a higher risk of obesity, compared to those with no domestic helpers (adjusted OR= 1.57; 95% CI: 1.01 to 2.45; p<0.05) (al-Isa and Moussa, 1999). These findings suggest those living in higher SES, urban areas employing more domestic helpers were at an increased risk of developing overweight and obesity during the preschool years.

2.4.2.3.2 Age and gender

Two studies investigated associations between gender and obesity risk (al-Isa and Moussa, 1999; Al-Qaoud and Prakash, 2009). Both studies reported that the risk of overweight and/or obesity was higher in girls compared to boys. Al Qaoud and Parkash (2009) found that the risk of being obese was 32% greater in girls compared to boys (adjusted OR=1.32; 95% CI: 1.01 to 1.72; p= 0.04). Likewise, Al-Isa and Moussa (1999) reported that the risk of obesity was 54% greater for girls compared to boys (adjusted OR=1.54; 95% CI: 1.22 to 1.94).

In relation to age differences, whilst Al-Hazzaa and Al-Rasheedi (2007) found no association between obesity and age, Al Qaoud and Parkash (2009) and Al-Isa and Moussa (1999) found that the eldest group of children were at a higher risk of becoming overweight or obese, compared to the youngest groups. For instance, Al Qaoud and Parkash (2009) showed that the risk of obesity was 2.6 times higher in children aged over 5 years, compared to children younger than 4 years (adjusted OR= 2.63; 95% CI: 1.84 to 3.77). However, overall findings from the included studies suggest that overweight and obesity risk increases with age, and girls have a higher risk compared to boys.

2.4.2.3.3 Parental obesity and parental education

One study found that children of obese mothers had a greater risk of being overweight or obese compared to children of normal weight mothers (for overweight: adjusted OR= 1.94; 95% CI: 1.22 to 3.07, for obesity: adjusted OR=2.63; 95% CI: 1.76 to 3.93) (Al-Qaoud and Prakash, 2009). Two studies examined the association between maternal education and obesity risk. However, the results were conflicting. Al Isa and Moussa (1999) found a higher risk of overweight and obesity among children of mothers with medium levels of education compared to those with a lower level of education ($p<0.001$), whereas Alawi et al. (2013) found no such association.

2.4.2.4 Early life risk factors

Two studies examined associations between infant characteristics (birth weight, breastfeeding duration, age of introduction of solids) and obesity (Al-Qaoud and Prakash, 2009b, Alawi et al., 2013).

2.4.2.4.1 Birth weight

Al Qaoud and Parkash (2009) found that birth weight >4kg was associated with twofold risk of obesity in preschool children compared with those with birth weight between 2.5kg and <4kg (adjusted OR= 2.06; 1.40 to 3.03; $p<0.001$). Similarly, Alawi et al. (2013) found that infants born large-for-gestational age had a higher risk of overweight and obesity in preschool.

2.4.2.4.2 Breastfeeding

Alawi et al. (2013) reported that mixed fed infants (given breast and formula milk) had a higher prevalence of preschool overweight and obesity compared to those who were exclusively breastfed. Conversely, Al Qaoud and Parkash (2009) found no association between duration of breastfeeding and overweight and obesity in preschool children.

2.4.2.4.3 Complementary feeding

Al Qaoud and Parkash (2009) found that the early introduction of solids (defined as before 3 months old) was significantly associated with an increased risk of becoming overweight (by 2.4 times) or obese (by 2.5 times) compared to those in whom solids were introduced between 4 and 6 months (for overweight: adjusted OR= 2.39; 95% CI 1.23 to 4.63, for obesity: adjusted OR= 2.46; 95% CI: 1.16 to 5.18). However, Alawi et al. (2013) found no association between the timing of solid food introduction and overweight and/or obesity in preschool children.

2.4.2.4.4 Diet

None of the included studies focused on the association between diet and obesity risk. However, Al Isa and Moussa (1999) suggested that children who had an irregular or no regular meal pattern had a higher risk of overweight and obesity, compared to children with regular meal patterns ($p<0.05$).

2.4.2.4.5 Physical activity and sedentary behaviour

Associations between physical activity and sedentary behaviour with overweight and obesity was examined in a study from Saudi Arabia. Al-Hazzaa and Al-Rasheedi (2007) found that parent-reported time spent watching TV was significantly higher in obese children, compared to non-obese children (197.5 v 60.9 mins per day; $p<0.001$). However, no association was found between physical activity measured objectively, using step counts per day, and obesity.

2.4.3 Discussion

Despite a comprehensive search, no previous systematic review focusing on risk factors of preschool overweight and obesity within the Arabian Gulf region was found. Therefore, to the best of my knowledge this present systematic review appears to be the first to provide evidence on key determinants of overweight and obesity in preschool children in the UAE and neighbouring GCC countries. The current review identified several risk factors, which were consistent with findings reported from other developing countries (Caballero, 2007; Gupta et al., 2012; Popkin et al., 2012). Findings are discussed and compared below.

2.4.3.1 Non-modifiable risk factors of preschool obesity

2.4.3.1.1 Ethnicity

The association between a higher risk of obesity and ethnicity has been documented extensively in both developed and developing countries (see section 2.2.3) (Singh et al., 2008b; Stamatakis et al., 2010). However, in the UAE and neighbouring GCC countries, there is little evidence of ethnic disparities in health outcomes. For example, a recently published census from the Federal Competitiveness and Statistics Authority (National Bureau of Statistics, 2011) in the UAE provides no reference to ethnic categorisation. One explanation for this is that the Emirati population is homogenous, of Arabic origins. However, it could be that that the population simply has not been assessed with respect to ethnicity, and therefore no study has addressed the role of ethnicity and risk of obesity.

2.4.3.1.2 Socioeconomic status

The tremendous socioeconomic changes in the Arabian Gulf region following the oil boom during the 1960s increased affluence and the accessibility of imported, Western products (Styne, 2005). Food prices decreased (particularly for energy dense Western foods) relative to increasing incomes. Therefore, food became more available. At the same time, physical activity levels substantially declined following the increased use of cars, lifts and buses (Popkin and Gordon-Larsen, 2004; Musaiger, 2011b). Therefore, both sides of the energy balance were influenced to favour obesity development.

The relationship between SES and obesity shows interesting asymmetry between developed and developing countries, as previously discussed in section 2.2.4 (Wang and Lobstein, 2006; Gupta et al., 2012). In developed countries, children of low SES are at an increased risk of obesity (Wang and Lobstein, 2006; Shrewsbury and Wardle, 2008). In contrast, obesity is found to be associated with high-income status in developing countries, e.g. in India (Gupta et al., 2012; Mistry et al., 2016). Similar findings would be expected in the UAE and neighbouring countries.

However, in the GCC, there is no official socioeconomic categorisation of the population (Shah et al., 1998) and inequalities at the societal level are not clearly stated. Nevertheless, one study included in this review found that children in middle and high SES (according to parent education, occupation and income) are at an increased risk of becoming overweight or obese, hence the influence of SES is similar to other developing countries and not Western countries

This could be explained by cultural attitudes towards body weight. Attitudes towards weight and body size are often culturally influenced, as shown by the diversity of body weight among different cultures (Caprio et al., 2008; Peña et al., 2012; Elran-Barak et al., 2015). Many researchers in the region have suggested that the socio-cultural norms force parents to ensure ‘plumpness’ among themselves and their children as a sign of beauty and affluence. As a result, energy-dense food is highly integrated into their everyday diet and children are usually overfed (due to pressures to finish food offered)(al-Shammari et al., 1994; al-Isa, 1997).

Disparities in obesity risk between rural and urban areas have been reported in some studies in the Arabian Gulf region (Al Othaimeen et al., 2007; Badran and Laher, 2011). For example, in Saudi Arabia, the prevalence of preschool obesity was 4% among preschool children living in rural areas and 22% in those living in cities (El-Hazmi and Warsy, 2002). These differences could be explained by the limited exposure of families in rural areas to Western influences on food and lifestyle practices following the nutrition transition. Families living in rural areas may employ a traditional 'Bedouin' lifestyle, in which children are encouraged to play outside and food is limited to available local produce (Abdul-Rahim et al., 2003; Salazar-Martinez et al., 2006).

2.4.3.2 Modifiable risk factors of preschool obesity

2.4.3.2.1 Birth weight

The relationship between birth weight and obesity risk has been extensively documented in developed countries (see section 2.3.1.1). This relationship is important because maternal obesity is common in the UAE and neighbouring Arab Gulf countries (Jahan, 2016). Maternal obesity has been suggested to lead to foetal over nutrition (commonly known as the Foetal Over Nutrition Hypothesis) (Whitaker et al., 1998; Oken and Gillman, 2003; Ong and Dunger, 2004). This increases the risk of infants being born large for gestational age, which has, in turn, been linked to an increased risk of obesity in later life (Woo Baidal et al., 2016).

To date, no study in the UAE has assessed the association between birth weight and later obesity risk. However, the current systematic review found that, in Kuwait, a high birth weight was associated with a higher risk of overweight and obesity, which is consistent with findings from one systematic review by Woo Baidal et al. (2016). Hence, the findings of this thesis will offer insight into the relationship between birth weight and obesity among preschool children in the UAE.

2.4.3.2.2 Growth patterns

It is well established that faster growth/weight gain during infancy is associated with a greater risk of overweight and obesity in later life, as previously discussed in section 2.3.1.4. With respect to this review, no study to date has investigated the risk of fast growth and obesity risk among preschool children in the UAE or neighbouring Arabian Gulf countries.

2.4.3.2.3 Breastfeeding

In the UAE, the Ministry of Health has recognised the benefits of breastfeeding.[14] However, findings from the current systematic review found no studies investigating the relationship between breastfeeding and later obesity risk in the UAE. Hence, one aim of the current research is to investigate whether breastfeeding (either exclusivity or duration of breastfeeding) has any association with obesity risk among preschool children in the UAE.

Initiation rates of breastfeeding are high in the UAE, ranging between 95% and 98% (Fikri and Farid, 2000; Radwan, 2013; Gardner et al., 2015). However, exclusive breastfeeding rates have declined dramatically. Radwan (2013) found that 98 % of mothers initiated breastfeeding, but only 25% were exclusively breastfed at 6 months (Radwan, 2013). More recently, Gardner et al. (2015) reported that, although 95 % of mothers initiated breastfeeding, only 5% were exclusively breastfeeding at 3 months old (Gardner et al. 2015). Although these studies were carried out in the same Emirati population, the duration of exclusive breastfeeding differed between studies. One possible explanation for the varying durations of exclusive breastfeeding in the UAE could be the influence of traditional feeding practices. For example, following birth, mothers enter a '*Nifas*',[15] where many infants are introduced to water, herbal infusions (Aniseed drink and Grippe water), honey, and soft dates before 6 months, thereby reducing the period of exclusive breastfeeding for mothers following this practice (Radwan, 2013; Gardner et al., 2015).

Several other factors have also been suggested to explain the shorter duration of exclusive breastfeeding and early cessation of breastfeeding (Fikri and Farid, 2000; Gardner et al., 2015). For example, in the UAE, Gardner et al. (2015) found

[14] It is recommended by the Holy Qur'an that 'Mothers may breastfeed their children two complete years for whoever wishes to complete the nursing [period] (2:233)' In accordance with Islamic recommendations, the Ministry of Health (MOH) and the Federal National Council (FNC) in the UAE established a child right law to make breastfeeding mandatory for the first two years of an infant's life and recommends exclusive breastfeeding up to 6 months of age (Salem, 2014).

[15] *Nifas* (post-natal bleeding period) is a cultural norm in which mothers spend 40 days in their parents/family home.

that 36% of mothers introduced infant formula before 6 months to ensure sufficient weight gain. Other reasons for the early cessation of breastfeeding included: perceived insufficient milk (32%), infant feeding difficulties (12%), pregnancy (12%) and poor infant weight gain (10%). Hence, the shorter duration of exclusive breastfeeding and addition of infant formula (prior to 6 months) is suggested to be one factor contributing to the high risk of overweight and obesity in the Arabian Gulf region (Musaiger, 2007).

In relation to this review, although Alawi and colleagues (2013) suggested that mixed fed (formula and breast milk) infants were at a higher risk of obesity compared to those exclusively breast-fed in Bahrain, the study used retrospective data to define overweight and obesity, which could be a source of recall error (Alawi et al., 2013). Moreover, Al Qaoud and Parkash (2009) found no association between the duration of breastfeeding and preschool obesity risk in Kuwait. These findings highlight that the evidence for the relationship between breastfeeding and obesity is weak, and in need of further investigation.

2.4.3.2.4 Complementary feeding

Although research is limited, studies in the UAE suggest that 70% of mothers introduce solids between 4 and 6 months (Radwan, 2013). However, many mothers introduced solids earlier. For example, in the UAE, Gardner et al. (2015) observed that, by 3 months, 21% of mothers introduced commercial infant food, 19% introduced biscuits and 15% introduced fruit and vegetables (15%) (Gardner et al., 2015).

In Kuwait, 52% of mothers were found to introduce solids before 4 months (Al Awadi and Amine, 1997), although, more recently, Scott et al. (2015) found that only 33% of infants started solids by 4 months, indicating an improvement in compliance with global infant recommendations. In the UK, a similar trend has been found, where 51% of women introduced solids at 4 months in 2005 compared to 30% in 2005 (McAndrew et al., 2012). However, this trend has not been documented in other Arab Gulf countries.

Factors that influence the age of introduction of solids are relatively unclear in the Arabian Gulf region (Musaiger, 2007). In Western countries (see section 2.3.1.5) early introduction of solids has been associated with shorter breastfeeding duration, maternal smoking, education, age and socioeconomic status (Scott et al., 2009; Clayton et al., 2013). Reasons for early introduction of solids vary between countries in the Middle East region. These include insufficient milk supply, feeding problems (e.g. nipple pain), pregnancy, lack of family support, and mother's return to employment (Nasreddine et al., 2012).

In this review, no study investigated the association between the timing of solid introduction and obesity risk in the UAE. However, one study in Kuwait found that early introduction (before 2 months) increased the risk of becoming obese (by 2.5 times) compared to solids introduced between 4 and 6 months (adjusted OR= 2.46; 95% CI: 1.16 to 5.18) (Al-Qaoud and Prakash, 2009). This suggests an association between early introduction of solids and obesity risk in the Arab Gulf region. Hence, this thesis aims to investigate the relationship between the timing of complementary feeding and obesity risk among Emirati preschool children.

2.4.3.2.5 Diet

One of the biggest research gaps in the area of obesity risk factors in the UAE and neighbouring GCC countries is the lack of research on dietary risk factors. In fact, no study to date has investigated the association between dietary factors and obesity risk among preschool children. Hence, one of the main purposes of this current research is to understand the role of diet in relation to preschool obesity risk in the UAE. Therefore, dietary risk factors are addressed in a separate systematic review focusing on dietary patterns and obesity risk among preschool children (see Chapter 3, section 3.3).

2.4.3.2.6 Physical activity and sedentary behaviour

Modern transport (e.g. cars, buses) and technology (e.g. lifts, television, electronic devices) have markedly reduced physical activity globally (Pate et al., 2004; Must and Tybor, 2005; Timmons et al., 2012). Several studies have found that children who are likely to take part in physical activity (playing, running etc.)

are at a lower risk of being overweight or obese (te Velde et al., 2012). Similar factors are likely to be relevant to the Middle East.

Physical activity is restricted in this region because of the hot climate (temperatures reaching 50°C), lack of sidewalks and/or parks, and dependence on domestic helpers (Musaiger et al., 2012a). Physical activity may be particularly low in the UAE and has been reported to be decreasing among children of all age groups following the nutrition transition (Ng et al., 2011).

Physical activity has also been suggested to differ between genders in the UAE. For example, Ng et al. (2011) showed that 27% of boys (aged 6-10 years) engaged in moderate to high levels of physical activity, compared to 20% of girls. These gender differences could be explained by the prevalence of obesity in the Middle East, where physical activity is challenging for many women within the Arab culture (Musaiger, 2007). This is supported by the current review, which found that girls are at a higher risk of overweight and obesity (al-Isa and Moussa, 1999; Al-Qaoud and Prakash, 2009). It is possible that social and cultural constraints adversely influencing physical activity in older women could also influence physical activity in young girls. This gender difference in physical activity could, in turn, influence obesity risk in girls and may potentially explain the higher risk of overweight and obesity in girls compared to boys.

Overall, this systematic review did not find strong evidence for an association between physical activity and obesity risk among preschool children in the UAE and neighbouring Arab Gulf countries.

An association between sedentary behaviour (TV viewing time) and obesity risk was found in one study in Saudi Arabia (Al-Hazzaa and Al-Rasheedi, 2007). This could possibly be explained by the increased use of electronic devices such as computer games and television viewing, and by the presence of domestic helpers (Badran and Laher, 2012). However, the study by Al-Hazzaa and Al Rasheedi (2007) did not report such data, or include dietary data, therefore it was not possible to know whether television viewing promoted high calorie intake of energy-dense food and beverages, which has been documented in Western countries to partly explain the association between TV viewing time and obesity risk (see section 2.3.2.1) (Giammattei et al., 2003; De Craemer et al., 2012). Hence, findings from this thesis would provide an insight on the contributing factors of preschool obesity by investigating physical activity, sedentary behaviour and dietary intake.

2.4.3.2.7 Sleep pattern

Although an association between short sleep duration and greater risk of obesity among preschool children has been suggested in several studies (see section 2.3.2.2), no study has examined this in the UAE and neighbouring Arab Gulf countries. One study, in Saudi Arabia, investigated this in older children, and found that sleeping fewer than seven hours increased the risk of obesity in children aged between 10 and 19 years (Bawazeer et al., 2009). Thus, sleep may be an important factor to consider in the prevention of childhood obesity, in addition to physical activity and diet.

2.4.4 Strengths and Limitations of this review

The main strength of the current review is its focus on the preschool period, which is a key time for the development of overweight and obesity. To the best of my knowledge, this is the first systematic review investigating the risk factors of preschool overweight and obesity in the UAE and neighbouring Arab Gulf countries.

A key limitation of this review is the small number and relatively poor quality of included studies. Although two studies included a large representative sample of preschool children (al-Isa and Moussa, 1999; Al-Qaoud and Prakash, 2009), the remaining two included smaller samples and so data are limited. Methods used to assess risk factors varied widely between studies, and definitions of overweight and obesity differed, making comparison between studies difficult. Also, the cross-sectional nature of studies means that a causal link cannot be established between identified risk factors in preschool children and the risk of obesity in later life.

2.4.5 Conclusion

This review highlighted a lack of research investigating risk factors for obesity in preschool children. Available data suggest similar risk factors to Western populations (Woo Baidal et al., 2016, Patro-Golab et al., 2016), including high birth weight, early introduction of solids and maternal BMI. However, data on dietary risk factors was completely absent.

Identifying early risk factors of preschool obesity is crucial to implement suitable preventative strategies tailored to different populations. Although this systematic review provides some evidence on the determinants of preschool obesity, it emphasises the need for more research. This should be of a longitudinal design to identify risk factors associated with preschool obesity in the UAE, including dietary risk factors.

This PhD thesis aims to address the gaps in the research and to develop and test simple, adaptable interventions that can be used in future studies in the UAE and throughout the Arabian Gulf region.

2.5 Chapter summary

Clearly modifiable and non-modifiable risk factors are associated with overweight and obesity in preschool children. Of these, research has particularly focused on the role of Developmental Origins of Health and Disease (DOHaD), which provides indications to support associations between early life risk factors (e.g. fast growth, breastfeeding) and later obesity risk. However, this evidence is mainly from Western countries, and whether early life risk factors can be extended to populations outside Europe has not been adequately addressed. The systematic review underscored the infancy of research focused on identifying risk factors of preschool overweight and obesity in the Arabian Gulf region, and the absence of studies identifying such associations in the UAE. Therefore, to address this gap in the literature, a key aim of the current research is to describe and identify potential risk factors of preschool overweight and obesity in the UAE.

Table 2-3 Characteristics of included studies investigating preschool obesity risk factors in Kuwait

Author	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity risk	Analysis	Results	Risk of Bias
1. Al Isa & Moussa. 1999 **Kuwait**	Cross sectional study of randomly selected kindergartens in five governorates of Kuwait Between October 1994 and April 1995 3-5 years old n=3473 (50% boys)	Questionnaires used to collect demographic data, dental status, eating behaviour, number of servants, whether grandparents living at home, type of housing, parental occupation and educational level.	Overweight and obesity defined using NCHS/CDC Normal/below (<90th centile) or overweight/obese (>90th centile/95th centile)	Logistic regression analysis	Girls had a higher risk of overweight (AOR: 1.52 (95% CI: 1.25-1.86) and obesity (AOR: 1.54 (95% CI: 1.22-1.94) compared to boys. Risk of overweight (AOR: 1.86 (95% CI 1.35-2.56)) and obesity (AOR: 2.36 (95% CI 1.59-3.51)) was higher for the eldest age group (60-71 months) compared to the youngest age group (36-47 months). Risk of overweight was higher for the mothers with medium level of education compared to the lower lowest level of education (AOR: 1.51 (95% CI 1.02-2.23). Risk of overweight was higher for families with more than 3 servants compared to those having no servants (AOR: 1.57 (95% CI 1.01-2.45). Risk of overweight (AOR: 0.58 (95% CI 0.40-0.81)) and obesity (AOR: 0.62 (95% CI 0.41-0.93)) is lowest among medium SES families compared to lower SES families. Risk of overweight was lower in Ahmadi (semi-urban) (AOR: 0.68 (95% CI 0.48-0.95)) and Jahra (mostly rural) (AOR: 0.32 (95% CI 0.19-0.54)) compared to the capital (urban). Risk of overweight was lower among children eating regularly (p<005) vs. sometimes/no basis	12 MOD

MOD, moderate, Table continued on next page

Author	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity risk	Analysis	Results	Risk of bias
2. Al Qaoud & Parkash., 2009 **Kuwait**	Cross sectional study using data from the Kuwait Nutrition Surveillance System (KNSS). Between September 2003 and June 2004 3-6 years old n=2,291 (48% boys)	Questionnaires used to collect demographic, maternal and child characteristics (e.g. birth weight) and infant feeding data.	BMI calculated to define overweight and obesity using CDC growth charts. (overweight >85th percentile, obese >95th percentile)	Multi-nominal logistic regression applied to estimate the risk of different factors in overweight and obese children after controlling for confounding factors	The risk of obesity was higher for girls compared to boys (AOR=1.32, 95% CI: 1.01-1.72) (P=0.04). Children aged 4 - <5 years had a higher risk of overweight (AOR= 3.00, 95% CI: 1.99-4.51) and obesity (AOR = 2.82, 95% CI: 2.00–3.98) compared to children aged less than 4 years. Children aged > 5 years had a higher risk of overweight (AOR=2.53, 95% CI: 1.64-3.91) and obesity (AOR=2.63, 95% CI: 1.84-3.77)) compared to children aged less aged less than 4 years. Birth weight >4kg was associated with a higher risk of obesity compared to a birth weight between 2.5kg-4kg (AOR: 2.06, 95% CI: 1.40-3.03) Risk of becoming overweight (AOR=2.39, 95% CI: 1.23-4.63) and obese (AOR=2.46, 95% CI: 1.16-5.18) was higher for the introduction of solids before 3 months, compared to solids introduced between 4 and 6 months. Risk of overweight (AOR=1.94, 95% CI: 1.22-3.07) and obesity (AOR=2.63, 95% CI: 1.76-3.93) was higher among children with obese mothers compared to children with mothers of normal weight. No significant association was found between overweight/obesity and duration of breastfeeding (p>0.05).	16 MOD

MOD, moderate

Table 2-4 Characteristics of included studies investigating preschool obesity risk factors in Saudi Arabia and Bahrain

Author	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity risk	Analysis	Results	Risk of bias
3. Al Hazza & Al Rasheedi, 2007 **Saudi Arabia**	Cross sectional study of randomly selected public and private schools in Jeddah, Saudi Arabia Between April and May 2006. 2-4 years old n=224 (49% boys)	Habitual physical activity assessed using electronic pedometer (Digi walker) for 3 weekdays to provide daily step count. Questionnaire used to collect demographic and television viewing time	Adiposity (fat mass index) defined using Slaughter prediction equations.	Independent t-test used to report difference between obese and non-obese groups. All data presented as mean (SD)	No difference between obese and non-obese children for both age and step counts per day (p>0.05). TV viewing (minutes per day) was higher among obese children (197.5 (89.3) compared to the non-obese children (150 (60.9)) (p<0.001). No difference between Active and Inactive group in relation to fat mass index, TV viewing time and all other anthropometric variables (p>0.05).	9 Poor
4. Al Alawi et al., 2013 **Bahrain**	Cross sectional study of four local health centres randomly selected across Bahrain using retrospective data n=387 children Aged 3-60 months	20 item questionnaires used to collect demographic, parental education, occupation, duration of breastfeeding, age of solids, birth weight from local health centres for children	BMI used to define overweight and obesity using NCHS/CDC references	Chi squared test was used to compare overweight and obese children with normal weight children across different factors (age, parental educational status, maternal work status, birth order, birth weight and type of feeding)	No association between was found between parental education, working mothers, birth order with overweight and obesity among children. Children born large for age had a higher prevalence of overweight and obesity at follow-up (p=0.01). Mixed fed infants (breast and formula) had a higher risk of overweight and obesity compared to those only breastfed (p>0.05) No association was found with time of solid introduction (p>0.05).	8 Poor

Chapter 3 Dietary determinants of preschool obesity

Let food be thy medicine and medicine be thy food – Hippocrates

3.1 Introduction

Good nutrition in early life is essential for growth, development and long-term health. A poor diet on the other hand can have a substantial impact on a child's short and long-term health and nutritional status (e.g. dental caries, micronutrient deficiencies and overweight and obesity) (Craigie et al., 2011). In addition to developmental and lifestyle risk factors discussed earlier in Chapter 2, dietary factors presenting in the preschool years have also been suggested to influence the obesity epidemic (Popkin, 2001; World Health Organisation, 2003b).

The preschool years are considered a key period during which long-term dietary habits are established (Nicklas et al., 2003; Birch et al., 2007). A healthy, balanced diet based on foods from the major food groups, high in fruits, vegetables, and adequate in fibre is important during this period. However, in the current modern environment, which offers a diverse range of readily accessible energy dense food, the diets of children are often found to be suboptimal. For instance, in the UK, only 12% of 5-year-old children met the recommended five servings of fruit and vegetables a day (Deverill et al., 2002), and in the UAE, 60% of primary-school-aged girls (7 to 14 year old) consumed energy dense snacks (chocolates and chips) on a daily basis (Ali et al., 2013). Hence, the diets of preschool children is an area of high interest, and understanding the relationship between diet and obesity risk has become a key focus for research.

Several dietary determinants have been proposed to influence childhood obesity risk in developed countries. These include a low intake of fruit, vegetable and fibre, and a high intake of energy, fat, protein and sugar (Ledoux et al., 2011; Brauchla et al., 2012; Hu, 2013; Pate et al., 2013). As previously highlighted in a systematic review of studies investigating risk factors for preschool obesity in the UAE and neighbouring Arab Gulf countries (see section 2.4), the impact of dietary factors in preschool on obesity risk is poorly researched in this region. Therefore, a key aim of the current research is to investigate the influence of dietary factors on preschool obesity risk in the UAE. This could aid the development of nutritional interventions to prevent the current obesity problem in this region.

This chapter aims to address nutrition and preschool obesity, focusing on both dietary intake and dietary patterns. The chapter is divided into three sections: (i) an overview of the dietary assessment techniques used in children; (ii) a review of the dietary risk factors for obesity in preschool children; (iii) a systematic review to investigate associations between dietary patterns and preschool obesity risk from both cross-sectional and longitudinal studies, to provide a greater understanding of these associations for future research in the Arabian Gulf region.

3.2 Assessing diet

Accurate dietary assessment is important in determining nutritional adequacy and identifying those at risk of disease, e.g. overweight and obesity (Livingstone et al., 2004). However, accurate assessment of children’s diet is difficult because young children do not have the cognitive ability to recall or estimate their dietary intake, and so investigators rely on parents/caregivers to report the dietary intakes of children (Livingstone and Robson, 2000; Burrows et al., 2010; Jarman et al., 2014). This may prove difficult if the child consumes food outside their parents’ supervision (e.g. in a preschool setting or with grandparents). Estimating portion sizes may also be problematic. Although parents/caregivers report the amount of food given, it may not reflect the actual amount consumed (e.g. children may swap foods with other children in the preschool setting, or give away food). Lastly, because young children’s dietary habits are found to change rapidly, capturing habitual diet may prove difficult (Stein et al., 1991; Serdula et al., 2001).

Nevertheless, several methods are used to assess the dietary intake of children in research studies (Willett, 1998), each of which has advantages and disadvantages (see, Tables 3-1 and 3-2). Although the current research utilises one method of dietary assessment (food diaries; see section 6.8.7.1: for a description), for completeness, other methods of dietary assessment are discussed below. These are divided into retrospective and prospective measures of dietary intake (Kant, 2004).

3.2.1 Retrospective dietary assessment methods

Retrospective dietary assessment methods collect dietary data on food consumed in the past. These include: 24-hour recall, diet history and a food frequency questionnaire (FFQ).

3.2.1.1 24-hour recall

The 24-hour recall method involves recording comprehensive information about dietary intake over the preceding 24-hours. The recall is typically conducted through an interview, either in person, or by telephone. The aim is to obtain a complete record of intake, including an estimate of portion sizes, that will help the investigator quantify dietary intake. Interviewers are usually provided with a standardised form that includes probing questions to capture prior dietary intake. Probing is particularly useful in recovering dietary details which may have been forgotten by the respondent (e.g. butter on toast, or snacks consumed while watching TV).

The use of neutral, probing questions avoids leading the respondent to specific answers about their diet (Campbell and Dodds, 1967). Thus, although 24-hour recall shifts the burden of reporting from the respondent to the investigator (Burke, 1947), well-trained interviewers need to have sufficient knowledge about foods (e.g. preparation and processes) to aid the respondent.

Compared with other types of dietary assessment methods, 24-hour recall is also relatively brief to administer (10-20 minutes). However, the duration may vary according to the participants' literacy and their ability to remember consumed foods easily (Johnson et al., 1998). For example, individuals who prepare their meals from scratch may take longer to describe ingredients and preparation methods. Thus, in certain situations, a longer interview time (ranging between 20 and 60 minutes) is required.

Overall, the 24-hour recall method is relatively inexpensive, reduces respondent burden and is feasible for large-scale studies across different populations (Briefel, 1994; Sun et al., 2010; De Keyzer et al., 2011). Nevertheless, there are some limitations associated with this method (see, Table 3-2). The main disadvantage is that the single day ‘snap shot’ of dietary intake is seldom representative of an individual’s habitual diet, and disregards ‘day-to-day’ (e.g. weekday/weekend and seasonal) variation. Therefore, the collection of multiple 24-hour recalls is considered more accurate (De Keyzer et al., 2011). Additionally, the collection of multiple 24-hour recalls should be done using standardised methodology (e.g. training protocols for dietary assessment), and with the same researcher, to reduce inter-investigator variability.

3.2.1.2 Diet history

Diet history was originally devised by Burke (1947) in order to provide information about the frequency of intake and the makeup of meals consumed in the past (Burke, 1947). This method is generally used to describe habitual diet or usual food and/or nutrient intake over a long period that can range between 6 months and 1 year.

Dietary information is collected through a structured face-to-face interview by a trained investigator (usually a nutritionist or dietitian), using open-ended questions. A detailed interview about usual eating patterns, which may include a 24-hour recall, is considered the central feature of diet history. In some cases, a food list investigating the frequency of foods usually consumed and a 3-day diet record may also be used to cross-check the recorded diet history (Burke and Stuart, 1938; Burke, 1947).

The main strength of the diet history method is that it provides information on habitual intake of foods, rather than just a cross-sectional ‘snap shot’ of dietary intake. The use of open-ended questions also allows the investigator to get a clear picture of usual diet, and includes greater detail about foods and food groups consumed (e.g. enquire about different cooking methods, portion sizes and consider seasonal and weekday variations). The investigator also controls the questions, to prevent the respondent replying in a way that is expected. For example, an investigator may start by asking ‘What did you eat first?’ This is often followed by probing questions, such as ‘What did you have?’ ‘How much did you have?’ and ‘How was it prepared?’

Diet histories are more widely used in clinical settings than in research studies, where the aim is to assess diet and disease outcome relationships. However, this method requires the interviewer to have a high level of expertise and good knowledge of local food, in order to keep the respondent motivated, and ensure that the respondent does not make judgements about their usual food consumption (e.g. some individuals may over-report ‘good’ foods, and under-report ‘bad’ foods). Hence, many researchers have cautioned against the interpretation of nutrient intake estimated by diet history (Burke, 1947).

3.2.1.3 Food frequency questionnaire

Food frequency questionnaires (FFQ) are used to provide retrospective semi-quantitative information about the frequency of consuming food or food groups over a specific period of time, in order to assess habitual diet (Zulkifli and Yu, 1992; Willett, 1998).

The FFQ can be either investigator-administered or self-administered (Bingham et al., 2001). Although investigator-administered FFQs are favoured, in both cases participants are provided with a detailed explanation and instructions, in order to accurately report the frequency of consuming foods and drinks from a list (Block et al., 1990). To estimate food and nutrient intake and/or derive dietary patterns (Block et al., 1986), the food lists should include main sources of foods and nutrients, which may contribute to the variability of an individual’s diet, and should include foods commonly consumed in the study population.

Strengths of the FFQ are that it is relatively inexpensive to administer, the process of completing the questionnaire is less time-consuming (typically takes 10 to 20 mins), and dietary data is easier to code and enter into nutrient analysis programs, compared to other methods. Finally, the standardisation of responses collected allows the data from FFQs to be analysed quickly (See, Table 3-2) (Nelson et al., 1989; Willett et al., 1990).

However, the major limitations of FFQs include: the semi-quantitative nature of the questionnaires, which may not include important details of foods consumed (e.g. cooking methods, combinations of foods in meals, pre-prepared meals, take-away foods); the possibility of substantial measurement error as a result of incomplete listing of foods; and possible errors in estimating frequency and usual serving size (Kipnis et al., 2003; Subar et al., 2003). For example, many researchers have reported that FFQs tend to underestimate energy and macronutrient intake (Bedard et al., 2004) and overestimate micronutrient intake (Paalanen et al., 2006).

Also, although some FFQs have been developed and adapted for different populations and purposes (Block et al., 1986; Bingham et al., 1997), it is still important to consider the appropriateness of the FFQ in certain populations. For instance, FFQs developed in one country or specific population may not be suitable for use in other countries, unless dietary habits are found to be similar. The food lists are also less likely to reflect dietary patterns of the study population. Thus, it is important to use FFQs with caution in countries that have not validated the use of the FFQ or developed comprehensive food lists, such as Arabian Gulf countries.

3.2.2 Prospective dietary assessment methods

Prospective dietary assessment methods collect dietary intake at the time of consumption (Block, 1989). These include weighed records, observed weighed inventory and estimated food records.

3.2.2.1 Weighed records

Weighed records are considered the most accurate method of dietary assessment (Gibney et al., 2004). This method requires individuals to accurately weigh and record all food and drink consumed (and leftovers), then record this in a booklet provided by the study investigator. Respondents are advised to provide a complete description of foods/drinks, including brand names, preparation and cooking methods, and recipes of composite meals.

Multiple days are needed to give the most reliable estimate of foods and nutrients consumed (Bingham et al., 1997). Ideally, a 7-day record should be completed to include weekend variation, and avoid bias toward certain days (e.g. weekend vs weekdays). Although, the 7-day weighed food record is considered the 'gold standard' method of dietary assessment, studies validating weighed food diaries against doubly labelled water have found that under-reporting is common using this method, and is not limited to obese individuals (Livingstone et al., 1990).

The accuracy of recording dietary intake could be influenced by many factors. For example, a long period of recording could affect the accuracy of recording, and seasonal variation may influence dietary intake (e.g. summer vs. winter). Participation in a study may also lead to fatigue or burden the respondents, and/or it may alter the respondent's dietary behaviour, known as the Hawthorne effect (McCambridge et al., 2014). Food or beverage intake is known to be misreported during dietary assessment (Livingstone and Black, 2003). For example, respondents may under-report unhealthy foods or over-report healthier foods (e.g. fruit and vegetables), or appear to be more compliant with dietary recommendations than expected (Livingstone et al., 1990; Black et al., 1991).

Moreover, although weighed food records have improved during the past few years with the use of digital scales that automatically record food intake, this method is considered expensive, time consuming and requires respondents to be literate and numerate (Livingstone et al., 1990). The weighed record method also places a considerable burden on parents/caregivers who are required to accurately weigh and record their child's diet, and therefore could be a potential source of bias (see, Table 3-1).

3.2.2.2 Observed weighed inventory

Observed weighed inventory is a highly accurate method for quantifying dietary intake. However, it is considered more difficult than weighed records, as it places a greater burden on the investigator to weigh foods and drinks before and after consumption. Thus, this method is costly and can also introduce a high risk of bias, as respondents are observed and are more likely to change their usual dietary habits (Livingstone and Robson, 2000).

3.2.2.3 Estimated food records

An alternative method of dietary assessment is the use of estimated food records, or food diaries, to provide detailed information on food and nutrient intakes. This method relies on the participant or parent/caregiver estimating and recording the amount of food and drink consumed over a specified period of time in a food diary/booklet, using household measures (e.g. spoons and cups), photographs, or household objects (e.g. egg-sized potato) (Block, 1982). The use of food photographs is most commonly used to assist the estimation of dietary intake and maintain respondents' motivation. However, studies have shown that both adults and children find estimation of portion sizes using photographs a difficult task (Frobisher & Maxwell, 2003), and it may affect an individual's conceptualisation of portion sizes consumed (Nelson et al., 1994). Foods can also be weighed if the respondent chooses. However, unlike the weighed food records, the main purpose of this method is to reduce the burden on the respondent. Also, although food diaries are not as complex as weighed food records, the method requires an investigator to provide a clear explanation of how to complete the recording of foods, and ideally a trained interviewer is required to double-check food diary entries with the respondent (via telephone or face-to face).

Food diaries are widely used because of the lower respondent burden, and they have been shown to provide quantitative estimates of intake with an acceptable degree of accuracy, when compared with weighed records (Gibson, 2005). For instance, estimated food diaries (7-day food diaries) were found to be in closest agreement with 16 days of weighed intake, compared to the food frequency questionnaire and 24-hour recall among adults (Bingham et al., 1997).

Food diaries have been successfully used in numerous large-scale studies, and are considered an 'open-ended' method, which is not limited by food lists or interviewer bias. Unlike retrospective dietary assessment methods (e.g. FFQ), food diaries are widely used to assess the dietary intake of children and are found useful when investigating cross-sectional associations between dietary intake and obesity. Lanigan et al. (2001) validated the use of food diaries among young toddlers, and found an acceptable agreement in energy intakes when comparing estimated food records with weighed food records, and doubly-labelled water (Lanigan et al., 2001).

Lanigan et al. (2004) also suggest that relatively few days are needed to accurately measure a child's dietary intake from food diaries, ranging from 2 days for micronutrients (e.g. magnesium, iron etc.), 3 days for carbohydrates intake, 4 days for fat and protein intake, to 5 days for energy intake. For example, for 5-day food diaries, parents are encouraged to record 3 consecutive weekdays and 2 days during the weekend (Lanigan et al., 2004). The few days needed therefore reduce the burden of parents recording their child's intake, and minimises the risk of them misreporting their child's dietary intake.

Nevertheless, a limitation of this method is that it only provides an approximation of dietary intake. There is also a chance that individuals may record foods consumed from memory rather than concurrently, which may in turn affect eating behaviour and underestimate actual dietary intake (Buzzard and Sievert, 1994; Crawford et al., 1994) (see, Table 3-1).

3.2.3 Sources of error in dietary assessment

Errors in dietary assessment may occur during the recording of food intake. These may be random i.e. occurring among all subjects, or systematic, i.e. occurring repeatedly in some subjects. For example, obese individuals are consistently reported to under-report energy intake (Livingstone and Black, 2003; Rennie et al., 2007), which can in turn affect the accuracy of estimated intake for foods and nutrients. Biases may also arise due to reporting errors by the respondents, or through interviewer errors during the process of coding and entering the data.

As such, quality-control procedures are required at each stage of dietary assessment. These may include training for the interviewer and coder, and the use of validated questionnaires to ensure reproducibility and validity of measurements (Gibson, 2005).

3.2.3.1 Respondent error

Several factors have been suggested to influence the ability of the respondent to provide accurate dietary information. These include educational (literacy), social factors (age, sex, income), weight status and motivational factors (Gibson, 2005). For example, subjects may sometimes forget to report foods they have consumed. This is typically seen in elderly respondents who are more likely to have reduced recall powers (Livingstone and Black, 2003). In such cases, memory aids (e.g. food models, photographs) can be useful prompts to remind the respondent of foods they may have forgotten, and help them to accurately estimate portion sizes (Moore et al., 1967; Guthrie, 1984). The investigator may also opt to use probing questions to uncover foods that may have been consumed while, for instance, watching TV.

Bias may also arise if the respondent feels the need to give 'socially desirable' answers. For instance, when completing an FFQ that features desirable foods (e.g. fruits and vegetables) and undesirable foods (e.g. fried foods and sugary snacks), the respondent may lean towards the more desirable foods to avoid being judged (Livingstone et al., 1990; Pryer et al., 1997). For example, a study by Bingham et al. (1995), in the UK, found that respondents under-reported their intake of confectionery and cakes, compared to their reporting of potatoes, meat, fruits, vegetables and bread. Selective under-reporting of specific food items is also common. For instance, respondents may omit certain snacks, or foods that seem too tedious to record (e.g. dishes that contain more than one component, such as shepherd's pie) (Bingham et al., 1995) .

Generally, underreporting is considered a common source of respondent error (Beaton et al., 1983), which may affect the calculation of specific macro and micro-nutrients and energy intake (Briefel et al., 1997). To evaluate misreporting, energy intake is compared to predicted energy requirements expressed as a multiple of basal metabolic rate. A cut-off value of energy intake: basal metabolic rate is therefore calculated to identify under-reporters. The most widely used cut-offs to identify misreporters are the Goldberg cut-offs (Goldberg et al., 1991). Overall, it is important that sources of respondent error are taken into consideration (Nelson and Tucker, 1996), particularly when dietary data is used to examine the effectiveness of an intervention tool or weight loss programme (Buzzard and Sievert, 1994).

3.2.3.2 Interview error

Interview errors can be attributed to the interviewer, the subject, or both. In addition to respondent errors discussed earlier (e.g. over- or under-reporters), the interviewer may also introduce error.

Interviewer errors can arise from many sources, including incorrect use of probing questions, inaccurate recording of responses, or incorrect interpretation by the interviewer of the respondent's information (Fowler Jr and Mangione, 1990). Hence, it is essential that interviewers are trained using standard protocols, and quality control assessments are carried out in large-scale studies to reduce errors (e.g. using recording techniques) (Robertson et al., 2005).

Appropriate assessment of the interviewing processes should be considered. For example, interviewer bias can be assessed by comparing dietary intakes calculated by multiple interviewers using the same population within the same 24-hour period.

3.2.3.3 Database error

Following the collection of dietary data, records are coded, i.e. foods are converted into an amount in grams, allocated a food code, and entered into a nutrient database. A codebook is useful to help ensure standardisation of data entry. Several judgements must be applied when choosing the most appropriate code for each food item. For example, the provision of food labels allows the investigator to compare and check the nutrient content of food against those in the nutrient database. Hence, establishing a coding system is important to standardise within studies (Arab, 1985).

It is critical that investigators handling dietary data have the nutritional knowledge, training and tools needed to select the most appropriate food code. For instance, whilst coding an apple can be straightforward, it is more complicated when dealing with mixed dishes, where nutrient content is highly variable. Foods that have been cooked in different ways (e.g. fried, baked, boiled) will also need to be differently coded (Krebs-Smith et al., 1990). Hence, when collecting dietary data, details about food preparation and cooking methods are essential to guide judgements when choosing an appropriate food code.

During the process of coding and entering dietary data, errors may be introduced. For example, in some cases, dietary data could be entered incorrectly if the coder misreads information or transcribes it inappropriately. In other cases, the coder may not consider additional information provided by the respondent, which, in turn, can affect the final study findings (Beaton et al., 1979). For instance, if an individual reported eating a jacket potato with butter and the coder omitted the butter, the total energy and nutrient intake of that individual would be underestimated. To reduce this type of error, one or two investigators could crosscheck a proportion of the final dietary data (usually 1 in 10 of individual data) to identify mistakes that may have occurred during the process of coding and entering.

In summary, nutritional knowledge, training and the use of appropriate tools (i.e. validated methods, and a complete and accurate food composition database) are important to precisely assess dietary data, and produce accurate estimates of dietary intake.

3.2.4 Validity of dietary assessment methods

The aforementioned errors can affect the validity of dietary assessment. Validity is defined as the degree to which a measurement tool assesses the true exposure of interest, in relation to precision and accuracy (Bingham et al., 1997). Precision is related to the reproducibility of results. However, although precision focuses on ensuring a questionnaire used to measure dietary intake is consistent at different time points, absolute reproducibility is unlikely to be achieved, given that dietary intake is expected to show variation over time. Accuracy, on the other hand, describes how matched a measured value is to its actual or true value, measured using a more objective measure (e.g. biomarkers, doubly labelled water). For example, the accuracy of energy intake estimated using dietary records can be assessed against doubly-labelled water, which provides a precise measure of metabolisable energy intake (Davies et al., 1994). The validity of dietary assessment methods can also be assessed against biomarkers**.** However, these methods are expensive (Bingham, 2002).

Table 3-1 Advantages and Disadvantages of prospective dietary assessment methods

	Dietary assessment method	Advantages	Disadvantages
Prospective	**Observed Weighed records** Requires a trained investigator to visit individual at each meal and weigh consumed food, and the researcher returns to weigh leftovers	Useful in cases where individuals are unable to keep records for themselves (e.g. elderly, children).	Demanding for subjects and investigators. Expensive
	Weighed records Requires an individual to weigh food and drink prior to consumption. Leftovers are also weighed	Gold standard method Provides a measure of portion sizes Does not rely on memory	High respondent burden and investigator training Misreporting Expensive in terms of time and cost of equipment
	Estimated records Similar to weighed records except the quantity of food and drink is estimated rather than weighed, using household measures (e.g. cups, spoons, food photographs or food models). Investigator is required to convert estimates into weights to calculate food and nutrient intake	Lower respondent burden than weighed records Low cost assessment	Lower accuracy when compared to weighed records. Misreporting

Table 3-2 Advantages and disadvantages of retrospective dietary assessment methods

	Dietary assessment method	Advantages	Disadvantages
Retrospective	**24-hour recall** Requires a trained interviewer to ask the respondent to remember in detail all food and drink consumed during the previous 24-hours It relies on an accurate memory of intake.	Usually quick (approx. 20 mins) Lower burden on respondents Can quantify intake Does not affect eating behaviour	Difficulty in describing food and portion sizes Difficulty in recalling food intake Requires a trained investigator; high investigator cost Requires more than one 24-hour recall to describe habitual intake
	Diet history Individuals food intake and usual meal pattern is assessed by a nutritionist or trained interviewer	Provides comprehensive information about usual diet Low burden on respondents Allows probing to give estimate of quality and quantity of habitual diet	Requires highly skilled and trained interviewer Costly Focuses on regular patterns, which may overlook dietary pattern changes
	Food Frequency Questionnaire Provides estimates of frequency of food consumption over a specified period of time.	Lowest respondent burden Cheap, simple and easy Provides information about habitual intake Suitable for large scale studies Can be self-completed and posted Can be used to identify dietary patterns	Development of questionnaire is time consuming Estimation of portion sizes Not fully quantitative (extra work is required to convert into nutrient or food group) Possibility of under and over-reporting of food consumption.

3.3 Dietary factors and obesity risk

Diet is a complex exposure and a major lifestyle-related risk factor for a wide range of chronic diseases (including obesity). Therefore, understanding the impact of dietary factors on disease from early life is important.

Dietary habits are established during the preschool period, and are found to track into later life (Fisher et al., 2003). Correspondingly, obesity is often established before the age of five (Gardner et al., 2009) and is found to progress into adulthood (Nader et al., 2006). Dietary factors have been reported to influence obesity risk among preschool children (Nicklas et al., 2003; Reilly et al., 2005; Emmett and Jones, 2015). Therefore, the preschool years are an ideal target for intervention.

The relationship between diet and obesity in preschool children is under-studied, due to the complexity of dietary exposures and difficulties in accurately assessing them. It is likely that the relationship involves an interplay between diet composition, dietary patterns, appetite and parental feeding influences (Carnell and Wardle, 2008). Also, it has proven difficult to study relationships between diet and outcomes (e.g. obesity) in this age group, since both prospective longitudinal studies and cross-sectional studies are lacking. Studies investigating the relationship between dietary determinants and preschool obesity have focused on the role of energy or macronutrients (protein, fat and carbohydrates) (Rolland-Cachera et al., 1995; Malik et al., 2006; Günther et al., 2007). However, the evidence is conflicting and not clearly defined.

It is important to identify dietary factors that may have an impact on the risk of childhood obesity, to inform interventions that aim to improve diets and instil healthy eating at an early age. This is important in all countries, as the rates of overweight and obesity are high and rising globally. This is particularly true of countries in the Arabian Gulf, where the precise relationship of diet with the rapidly rising prevalence of childhood obesity is unknown (see section 2.4.3.2.5)

Thus, one aim of the current research is to investigate the association between dietary factors (focusing on dietary intake and dietary patterns) and obesity risk among preschool children in one such country: the United Arab Emirates.

3.3.1 Energy intake and obesity risk

It is widely accepted that a positive energy balance during the preschool years is a contributor to weight gain in childhood and later adulthood (Cowin and Emmett, 2000; Scaglioni et al., 2000; Birch and Davison, 2001; Stunkard et al., 2004; Garden et al., 2011; Hebestreit et al., 2014). However, evidence for an association between energy intake and preschool obesity is inconsistent.

Some studies have found an association between a high energy intake during the preschool years and later obesity risk (Cowin and Emmett, 2000; Stunkard et al., 2004; Öhlund et al., 2010). For instance, one study by Ohlund et al. (2010) found that total energy intake at 17-18 months old was associated with a higher BMI z-score at 4 years (R^2=0.061, β (SE) 0.002 (0.001); p=0.014) (Öhlund et al., 2010). Conversely, others have failed to find such an association, in both prospective longitudinal studies (Nicklas et al., 1988; Deheeger et al., 1996; Verduci et al., 2007) and cross-sectional studies (Atkin and Davies, 2000; Hakanen et al., 2006; Elliott et al., 2011). For example, findings from the STRIP RCT found that although energy intake was higher in obese children compared to children with normal weight, relative energy intake (in kilojoules per kilogram body weight) was lower in children who were obese compared to their normal weight peers (Simell et al., 2000).

The lack of association between energy intake and obesity could be explained by dietary assessment errors (Livingstone et al., 2004). These include: (i) errors in estimating intake e.g. snacks, portion sizes; (ii) the inability to recall dietary consumption accurately (especially when using retrospective methods; (iii) under-reporting of foods that are known to be energy dense by parents with heavier children; (iv) under-reporting of foods consumed outside parental supervision (Börnhorst et al., 2012).

The association of energy intake with a later risk of obesity could also be influenced by confounding factors. Total energy intake of preschool children is influenced by energy demands, which vary with respect to growth, body size, gender and physical activity (Hakanen et al., 2006; Swinburn et al., 2009). Hence, the estimation of energy intake could be at risk of bias and needs to be interpreted with caution.

Studies that have adjusted for possible confounding factors (e.g. body size) (Rolland-Cachera et al., 1995; Maffeis et al., 1998; Lakshman et al., 2012) were still unable to find an association between energy intake and obesity risk. This suggests that some studies may not take into account all confounding factors, such as a low level of physical activity. However, it could just reflect inaccurate assessment, as many studies just used single 24-hour recall or FFQ.

Physical activity levels are often reported as low among preschool children. Almost 60% of children do not meet the globally recommended 60 minutes of physical activity per day (see section 2.3.2.1), which could contribute to rising rates of preschool overweight and obesity (Atkin and Davies, 2000). Physical activity is one component of energy expenditure. Thus, more research, ideally including objective measures of energy expenditure (e.g. doubly labelled water) are needed. However, this method is difficult and costly.

Although studies investigating the relationship between energy intake and obesity risk are inconclusive, there is increasing evidence for the impact of macronutrient intake, and the source of energy e.g. energy from protein, fat and carbohydrates.

3.3.2 Macronutrient intake and obesity risk

The influence of macronutrient intake and childhood obesity has been investigated in numerous studies (Rolland-Cachera et al., 1995; Atkin and Davies, 2000; Scaglioni et al., 2000; Stunkard et al., 2004; Ambrosini, 2014).

3.3.2.1 Protein

In contrast to the limited evidence for an association between energy intake and obesity risk, research investigating the influence of protein intake on obesity risk is more substantial in the literature (Lanigan, 2016).

Although adequate protein intake during childhood is vital for growth, development and providing energy (Michaelsen and Greer, 2014), a high protein intake (>15% of energy) during infancy and early childhood is associated with an increased risk of subsequent obesity. The early protein hypothesis (Rolland-Cachera et al., 1995) suggests that a high protein intake may affect endocrine mechanisms, for example through higher insulin growth factor 1 that increases obesity risk (Martorell et al., 2001; Hörnell et al., 2013b; Michaelsen et al., 2013; Michaelsen and Greer, 2014).

Several studies support the early protein hypothesis. For instance, Gunther and colleagues found that a higher protein intake (14-15% of total energy intake) doubled the risk of being overweight in childhood compared to those who consumed a lower protein intake (11-12% of total energy intake) (OR= 2.34; 95% CI: 1.1 to 5.0) (Günther et al., 2007).

Likewise, a recent prospective study by Pimpin et al. (2016) found that a high protein intake (>15% of total energy) at 21 months was significantly associated with higher weight (β = 0.052 kg; 95% CI: 0.031 to 0.074) and higher BMI (β = 0.043 kg/m^2; 95% CI: 0.011 to 0.075) at 5 years of age (Pimpin et al., 2016). However, other studies have found no association (Cowin and Emmett, 2000; Dorosty et al., 2000). This could be due the lack of adjustment for confounding factors, or the influence of other dietary factors (e.g. fat and carbohydrate intake).

3.3.2.2 Fat

The amount of dietary fat consumed has been implicated as a causal or facilitating factor in the deposition of body fat, leading to obesity risk (Lissner and Heitmann, 1995). Possible explanations for the association between fat intake and obesity risk could be that fat contains twice the energy density of carbohydrates and protein (fat: 9 kcal/g vs carbohydrates: 4 kcal/g, protein: 4kcal/g). Also, the high palatability of fat could lead to passive consumption (Blundell and Macdiarmid, 1997). However, evidence of an association between fat intake and obesity risk among pre-schoolers is unconvincing.

Relatively few studies have suggested that a high intake of fat during childhood may increase the risk of later obesity (Tucker et al., 1997; Maffeis et al., 1998; Hooper et al., 2012). For example, findings from the STRIP RCT, which aimed to reduce the intake of saturated fat between 7 and 36 months of age, reported that, although saturated fat intake was lower in the intervention group compared to the control, there were fewer overweight girls but not boys in the intervention group at 10 years of age (Simell et al., 2000; Hakanen et al., 2006). Other studies have failed to find an association between fat intake and preschool weight gain (Dorosty et al., 2000; Rogers et al., 2001). This could be due to different study designs, and the influence of confounding factors, or a result of dietary assessment errors, where parents may under-report their child's intake of 'fatty foods'.

3.3.2.3 Carbohydrates

Few studies have investigated the relationship between carbohydrates and preschool obesity risk. A high carbohydrate intake (expressed as a percentage of energy) is often associated with a lower risk of childhood obesity (Gazzaniga and Burns, 1993; Nelson and Tucker, 1996; Tucker et al., 1997). This could be explained by several factors, including the lower energy density of carbohydrates compared to fats. Additionally, the slower rate of digestion of carbohydrates, due to their bulk and fibre, has been suggested to induce greater satiety, and reduce passive consumption, unlike dietary fats.

For instance, Scaglioni et al. (2000) prospectively followed up 1-year-old infants and reported that greater carbohydrate intake as a percentage of energy intake was associated with a lower BMI at 5 years of age. The mean consumption of carbohydrates in this study was significantly lower among those who were obese (44%) compared to those who were not obese (47%) (Scaglioni et al., 2000).

Among preschool children no study to date has found a positive association between carbohydrate intake and obesity risk (Deheeger et al., 1996; Atkin and Davies, 2000; Cowin and Emmett, 2000; Dorosty et al., 2000). Although the amount of carbohydrates per se may not be important in the development of obesity, the type of carbohydrate may be important. As such, there is greater emphasis on particular foods that make up carbohydrates, e.g. sugar intake.

3.3.2.4 Sugar

Sugar intake in children has dramatically increased in the period since the obesity epidemic began. There is increasing research investigating the influence of free sugars[16] in many countries. For example, in the UK, one third of energy intake in preschool children is reported to come from sugar (National Diet and Nutrition Survey, 2014). In 2014, the WHO published guidelines aiming to reduce daily sugar intake as a percentage of energy, from 10% to 5%. To achieve this, a reduction in intake of high sugar foods and beverages was recommended (Drewnowski et al., 2012; World Health Organisation, 2014; World Health Organisation, 2015).

Many researchers are currently investigating sugar intake in preschool children, particularly from sugar-sweetened beverages (Han et al., 2010). In the UK, the ALSPAC study reported that approximately 50% of 18-month-old children consume sugary drinks on a daily basis (Northstone et al., 2002). Several studies have reported an association between sugar sweetened beverages (SSBs)[17] and obesity risk in preschool children (Malik et al., 2009; Papandreou et al., 2013; Pan et al., 2014; Stevens et al., 2014). For instance, a prospective study of ~9600 preschool children, which investigated the influence of SSB with overweight, reported that higher consumption of sugar-sweetened beverages was associated with higher BMI z-scores in children aged 4 years OR: 1.17 (95% CI: 0.94 to 1.46)

[16] Free sugars include monosaccharides and disaccharides added to foods and beverages by the manufacturer, cook or consumer, and sugars naturally present in honey, syrups, fruit juices and fruit juice concentrates (World Health Organisation, 2015).

[17] SSBs include fruit drinks and carbonated drinks, which are composed of sucrose (equal quantities of glucose and fructose), high fructose syrups and fruit juice concentrates added to beverages. These beverages are high in sugar and contain more than 25kcal per 220ml (Malik et al., 2013).

and 5 years old OR: 1.43 (95% CI 1.10 to 1.85) compared to no consumption. The same study also found that children consuming more than one serving of sugar-sweetened beverages at 2 years of age had a greater increase in mean BMI z score at 4 years of age compared with those drinking less than one serving ($p<0.05$) (DeBoer et al., 2013).

Overall, evidence for the association of sugar-sweetened beverages with obesity risk is conflicting (Skinner and Carruth, 2001). Whilst some studies have found an association (Gillis and Bar-Or, 2003; Nicklas et al., 2003; Lim et al., 2009), others have not been able to (Gibson, 1998; Newby et al., 2004; O'Connor et al., 2006). This could be explained by the observational nature of studies, which can be confounded by residual or unmeasured factors, such as overall diet quality, consumption of other energy-dense foods, and type of sugar (e.g. total sugars, free sugars, intrinsic sugars, milk sugars) (Mathias et al., 2013).

Nevertheless, a systematic review (Malik et al., 2013) reported that sugar-sweetened beverages were positively associated with weight gain among children. A meta-analysis of seven prospective cohort studies found that a daily serving increase of sugar-sweetened beverages was associated with a 0.06 increase in BMI (kg/m^2) over 1 year (95% CI: 0.02 to 0.10). The same authors also reported findings from a meta-analysis of five randomised controlled trials in children, which found that interventions that aimed to reduce intake of sugar-sweetened beverages also reduced BMI (weighted mean difference in BMI, kg/m^2= -0.17 (95% CI: -0.39 to –0.05) (Malik et al., 2013). Therefore, evidence from this review supports an association between sugar-sweetened beverage consumption and weight gain in children. However, more research of a prospective longitudinal design and randomised controlled trials are needed before definitive conclusions can be made.

3.3.3 Other potential dietary factors that may influence obesity risk

3.3.3.1 Parental style and parental child-feeding practices

Parents undoubtedly influence a young child's food choices and behaviours, through their shared food environment. Parents also play an important role in establishing their child's food preferences and eating patterns, through both direct or indirect influences, such controlling a child's intake and/or passively modelling a healthy or unhealthy diet (Birch and Fisher, 1998; Cooke et al., 2004; Clark et al., 2007; Larsen et al., 2015). Research investigating these parental influences on a child's weight status have largely focused on; parenting styles, and parental child-feeding practices[18]. Four types of parenting styles described in the literature include: (i) *authoritative* parenting (uses high control over child's behaviour and also displays high warmth and responsiveness); (ii) *authoritarian* parenting (exerts high control, with low level of responsiveness or warmth); (iii) *indulgent* parenting (shows low demandingness/control and high responsiveness with less rules, but also exerts high engagement with a child's needs); (iv) *uninvolved* parenting (linked to low demandingness and low responsiveness) (Hughes et al., 2005).

Parental feeding style is considered a sub-category of parenting styles that is primarily related to mealtimes and feeding occasions. Therefore, the same dimensions of responsiveness and demandingness are applied to the context of child feeding (Ventura and Birch, 2008). These parental feeding styles have been widely investigated, and have been found to impact a child's behaviour, dietary preferences, and dietary habits (Rhee et al., 2006; Blissett and Haycraft, 2008; Hubbs-Tait et al., 2008).

Several studies have also linked parental feeding styles with childhood overweight and obesity (Chen and Kennedy, 2004; Sleddens et al., 2011; Vollmer and Mobley, 2013). For example, compared with an authoritative feeding style, in which parents may actively encourage a child to eat using supportive behaviours (e.g. a parent may use social praise to negotiate a child eats well),

[18] Parenting style is considered a general behavioural construct which describes how parents and children interact. Child-feeding practices refers to the behaviours used by parents to directly or indirectly influence their child's eating behaviour (Gevers et al., 2014).

parents using an authoritarian feeding style are found to encourage eating through specific rules and expectations (e.g. a parent may require a child to eat a certain food to avoid another) (Hughes et al., 2005). Therefore, children of authoritative parents are found to have better dietary habits and lower BMI, compared to children of authoritarian, indulgent or uninvolved parenting styles, which are found to have an unhealthy diet, and higher BMI (Rhee et al., 2006; Hughes et al., 2008; Gubbels et al., 2011; Shloim et al., 2015).

Parent child feeding practices, on the other hand, refer to specific goal-directed behaviours used by parents to directly influence their child's eating behaviour, by attempting to increase or decrease the intake of certain foods (Clark et al., 2007; Gevers et al., 2014). Feeding practices are usually divided into three aspects; pressure to eat, restriction and monitoring (Birch and Davison, 2001; Wardle and Carnell, 2007; Ventura and Birch, 2008; Blissett, 2011). However, these feeding practices can also include: modelling, restriction of certain food types, pressuring to eat, rewarding positive behaviours with food and the availability of food in the home environment.

Largely, parenting styles and parent child feeding practices have been suggested to influence dietary behaviours of children. For instance, a parent that uses authoritarian style of feeding would most likely restrict a child's ability to self-control their food consumption. Thus, children of authoritarian style parents are often found to be overweight compared to those that employ an authoritative feeding style (Vereecken et al., 2004; Rhee et al., 2006). Moreover, it has been suggested that restricting the consumption of specific foods (e.g. fatty/sugary foods) may increase the child's preference to those foods (Wardle et al., 2005), and may be associated with a higher child BMI (Shloim et al., 2015). In addition to restriction and pressure to eat, monitoring is also widely studied in relation to children's feeding style, and has been suggested to be protective against overweight (Birch and Davison, 2001; Ventura and Birch, 2008; Gubbels et al., 2011). However, several other factors may influence feeding practices, such as ethnicity, family eating behaviours, parent gender, family income and child age, and therefore need to be taken into consideration (Blissett and Bennett, 2013).

Despite the growing evidence that parental styles and child feeding practices may be instrumental in the development and/or maintenance of childhood obesity, not all studies have found such links (Agras et al., 2004; Blissett and Haycraft, 2008). This could partly be due to the fact that the interaction between parents and their child is bi-directional, and can be influenced by several environmental factors (e.g. cultural norms, income), parental characteristics (e.g. behaviours, beliefs, attitudes), and child characteristics (e.g. temperament, eating traits and learned behaviours) (Larsen et al., 2015; Shloim et al., 2015).

Moreover, although it is widely recommended that interventions aiming to encourage a healthy lifestyle and prevent childhood obesity should incorporate parenting style skills in relation to their children's feeding practices (Rhee et al., 2006; Scaglioni et al., 2008; Rudolf, 2017), few studies have incorporated these into obesity interventions.

3.3.3.2 Portion size, meal size, frequency and energy density

Overconsumption, as a result of eating too much (large portions or meal sizes) or eating too often (frequency of meals), has also been implicated to explain the rising prevalence of obesity. Over the past years, portion sizes and meal sizes have progressively become bigger, and serving sizes of ready-made food products have almost doubled, exceeding recommendations. For example, in the US, a typical muffin is 333% larger than the USDA recommendations (Young and Nestle, 2002; Fisher et al., 2003; Piernas and Popkin, 2011), which could consequently increase food intake and increase obesity risk (Fisher et al., 2003; Benton, 2004; Ledikwe et al., 2005).

Several studies have indicated that larger portion sizes, higher meal frequency and greater energy density could increase food intake, leading to weight gain. For example, Fisher et al. (2003) found that children aged between 3 and 5 years old who were given a meal double the age-appropriate size increased their energy intake by 15% (Fisher et al., 2003). Similarly, Kling et al. (2015) demonstrated that varying the portion size (by 100%, 150% or 200%) or increasing energy density (by 100% or 142%) of foods served to preschool children aged 3 to 5 years old independently influenced energy intake (Kling et al., 2015). Doubling the portion size (200%) increased total daily energy intake by 24%, and increasing the energy density of food to 142% increased energy intake by 40%, and simultaneously increased meal intake by 175kcal, irrespective of child age and body size.

Furthermore, a recent prospective study of ~1939 children from the Gemini twin cohort supports earlier findings. The study followed children from the age of 2 to 5 years, and reported that every 10kcal increase in meal size was associated with 1.5g weight gain per week. This promoted faster growth, regardless of frequency of intake (Syrad et al., 2016). Other studies have shown that heavier children exhibit poor satiety responsiveness, compared to their leaner peers (Carnell and Wardle, 2009; Webber et al., 2009). Reduced satiety can also lead to the consumption of larger meals and excessive weight gain (Syrad et al., 2016). Collectively, these findings suggest that, to reduce obesity risk, parents/carers need to control portion sizes and limit exposure to energy dense foods. Such actions may help to prevent overriding innate satiety cues (Matthiessen et al., 2003; Zheng et al., 2009), and may be useful in reducing the energy intake of preschool children without affecting acceptance (Kling et al., 2015).

3.3.3.3 Food Neophobia and Food Preferences

Acceptance of a wide variety of foods is central to the development of a healthy dietary pattern. Food neophobia, the rejection of unknown or novel foods, may therefore result in ‘unhealthy’ or poor dietary patterns (Dovey et al., 2008). Food neophobia is suggested to peak between the ages of 2 and 6 years, when children may start to explore their surrounding environment (Dovey et al., 2008; Wardle and Cooke, 2008; Perry et al., 2015). Their inherent adaptive trait therefore has been suggested to act as a protective function to reduce the risk of poisoning from unfamiliar food (Pliner, 1994).

However, in the current environment of abundant, safe, yet obesogenic food availability, food neophobia is found to adversely influence dietary habits. Given that humans are predisposed to prefer palatable sweet and salty flavours, this trait is found to influence the consumption of less palatable foods; fruits and vegetables, and therefore reduces overall diet quality and variety (Birch and Fisher, 1998; Cooke et al., 2006; Russell and Worsley, 2008). For example, Cooke et al (2003) explored the relationship between food neophobia and habitual diet in children aged between 2 and 6 years, and found a significant correlation between a high food neophobia score and reduced consumption of fruits and vegetables, but not sweet/fatty foods or starchy staples (Cooke et al., 2003).

Recently, several studies have investigated the relationship between food neophobia and obesity risk. However, the association is unclear. For instance, the NOURISH study found that ‘more neophobic’ children consumed fewer varieties of fruits and vegetables and obtained a greater proportion of their daily energy from discretionary foods (e.g. non-core foods, biscuits, crisps) at 2 years of age. However, no association was found between BMI z-score and food neophobia assessed using the Child Food Neophobia Scale (Perry et al., 2015).

These findings are supported by a recent systematic review of 41 studies (Brown et al., 2016). The review found no association between food neophobia and overweight or obesity in later life. Brown et al. (2016) highlighted that the heterogeneity in definitions of food neophobia and the wide variation in prevalence of food neophobia ranges between 5.8-59%, could have obscured the association. However, a greater understanding of the relationship between food neophobia and obesity could help health professionals and parents in the management of food neophobia and inform strategies to improve diet quality (Brown et al., 2016).

An in-depth study of food neophobia is beyond the scope of this thesis. However, findings of studies so far suggest that identifying neophobic children at an early age may be important and may help prevent the development of unhealthy dietary habits (Russell and Worsley, 2008).

3.4 Dietary patterns

Historically, nutrition research has focused on relationships of single foods and/or nutrients with the risk of disease (Dietz, 2006; Newby, 2007). This approach has provided insight into associations between dietary risk factors and childhood obesity (Willett, 1998; Grant et al., 2004). However, the interpretation of findings from studies that focus on single foods, food groups or nutrients is difficult, because it does not take into account that foods are eaten in combination, and interactions between nutrients are likely to exist (Moreno and Rodríguez, 2007).

The human diet is complex; free-living people do not consume foods and nutrients in isolation, but rather eat a varied diet. Therefore, diet and disease relationships are hampered by correlations often found between nutrients that occur in foods consumed together.

In recent years, nutritional epidemiology has shifted towards the study of dietary patterns and their relationship to disease. Dietary pattern analysis was described by Kant (2004) as ‘a dietary evaluation in which multiple dietary characteristics (foods and/or nutrients) are examined simultaneously or collectively rather than individually’ (Kant, 2004), to reflect the multi-dimensional nature of the whole diet. This can be used to complement traditional methods of dietary analysis (Jacques and Tucker, 2001; Hu, 2002).

Epidemiological studies have suggested that dietary patterns established during the preschool years track through childhood (Mikkilä et al., 2005; Robinson et al., 2007; Northstone and Emmett, 2008). For instance, similar dietary patterns were identified at the ages of 3, 4 and 7 in a large UK birth cohort (ALSPAC study) (Northstone and Emmett, 2008). Hence, understanding whether dietary patterns established during this period are associated with the development of diseases (e.g. obesity) during childhood and later life (Ambrosini, 2014), has become a target for research (Northstone and Emmett, 2008; Smithers et al., 2011). The potential of deriving dietary patterns offers a greater understanding of diet and disease relationships (Jacques and Tucker, 2001; Hu, 2002; Kant, 2004; Schulze and Hoffmann, 2006).

Two main approaches have been developed to derive dietary patterns or assess diet quality: (i) the theoretical or *a priori* approach, which uses current nutritional knowledge to define dietary indices or scores, e.g. using dietary guidelines to identify a high quality diet score (Ocké, 2013); (ii) the empirical or *a posteriori* approach which uses data-driven exploratory methods to derive dietary patterns from study specific dietary data, e.g. using multivariate analyses, factor analysis, principal component analysis and cluster analysis (Hu, 2002). More recently a third approach, known as the hybrid method, has gained popularity, which uses both *a priori* and *a posteriori* methods to derive dietary patterns, for example through reduced rank regression.

For the purpose of this thesis, I will focus on defining dietary patterns using two approaches, an *a priori,* hypothesis-driven diet score and a *posteriori* data-driven dietary pattern using principal component analysis.

3.4.1 Defining *a priori* dietary patterns

A priori defined dietary scores or indices are developed to assess overall diet quality by rating an individual's intake against guidelines (Ocké, 2013). Generally, diet scores sum the frequency or number of foods/food groups consumed, and are used to measure how well an individual or population is adhering to dietary guidelines (Michels and Schulze, 2005). Several dietary scores or indices have been developed, based on national or international dietary guidelines, or guidelines for the prevention of a specific disease (Fransen and Ocké, 2008). Generally, dietary scores are derived through classification into one of three categories: (i) nutrient intake, (iii) consumption of specific foods or food groups, or (iii) a combination of both categories (Kant, 2004; Fransen and Ocké, 2008).

The degree of adherence to dietary recommendations is then used to define dietary patterns using a score or index. Higher adherence to a particular dietary guideline usually equates to a healthier or higher quality diet (Lazarou and Newby, 2011; Marshall et al., 2014). For example, the Healthy Eating Index measures how well an individual diet conforms to the food pyramid developed by the US Department of Agriculture and, in turn, reflects nutrient adequacy and dietary variety (Kennedy et al., 1995; Michels and Schulze, 2005). Using the Healthy Eating index, individual diet scores are given for the consumption of fruit, vegetables, dairy, meat, legumes, oils and saturated fats. The sum of points from each food group then provides a measure of diet quality (points closer to 100 have a higher adherence to dietary guidelines, which equates to a healthier diet) (Ocké, 2013).

The use of dietary scores is increasing internationally among highly diverse populations (Marshall et al., 2014). Various diet scores have been modified to accommodate local dietary habits, and others have been developed for specific population groups. For example, some diet scores have been developed specifically for children (see, Table 3-3), using food-based dietary guidelines specifically developed for children to promote optimal growth and health.

The use of dietary scores/indices in children has several strengths, which include: (i) the ability to successfully translate dietary guidelines or nutritional knowledge into a single score/index to reflect adherence to a healthy diet quality; (ii) Dietary scores/indices are able to simply reflect dietary quality, adequacy, variety or diversity, (iii) they are associated with socio-demographic characteristics and health outcomes (e.g. obesity) (Lazarou and Newby, 2011). However, limitations include: (i) the large variety of diet scores/indices used in the literature, with a limited number developed specifically for preschool children; (ii) the type of dietary assessment methods (e.g. FFQ, food diaries) used to collect dietary data and derive dietary scores/indices vary widely between studies, which in turn makes comparisons difficult; (iii) most studies use diet scores and indices to describe diet quality, and little research has focused on investigating associations between dietary scores/indices in preschool children and health outcomes.

Overall, dietary scores are culturally and regionally specific, and therefore they are not universally applicable (Moeller et al., 2007). For instance, in the Arabian Gulf region, the lack of food-based dietary guidelines for children limits the development of appropriate dietary scores. Although many researchers in this region have opted to use dietary scores developed in Western countries, these may not accurately reflect the dietary patterns of the chosen population.

3.4.2 Defining *a posteriori* dietary patterns

Unlike the *a priori* approach, *a posteriori* methods use data-driven exploratory statistical analyses to identify dietary patterns of a population from available dietary data. These include Principal Component Analysis (PCA) and Cluster Analysis (CA) (Kant, 2004; Newby and Tucker, 2004).

The most common method of obtaining dietary patterns is principal component analysis (Northstone and Emmett, 2008; Emmett et al., 2015). Once dietary data are collected from the population of interest, usually using food diaries or food frequency questionnaires, food items are grouped according to their nutritional similarities (e.g. whole milk, cream, yoghurt, can be grouped as high fat dairy).

Principal component analysis utilises correlations that exist between different foods/food groups, and identifies linear combinations of foods that are frequently consumed together (Emmett et al., 2015). Following statistical analysis, each subject is given a score (known as a factor loading score) for every dietary pattern that emerges from the dietary data (Schulze and Hoffmann, 2006; Moeller et al., 2007), and dietary patterns are named in relation to the highest factor loadings (often those with eigenvalues greater than 2. See section 6.10.1.2.3 for a detailed description of PCA).

Cluster analysis, on the other hand, derives dietary patterns based on differences in dietary intakes between individuals. Based on similarities of dietary intake, this statistical technique assigns individuals into mutually exclusive (non-overlapping) groups, commonly known as clusters (Hu, 2002; Crozier et al., 2006; Moeller et al., 2007).

Typically, certain dietary patterns have been reported across populations, often labelled as a healthy/health conscious dietary pattern (high in fruit, vegetable, whole grains, and low in processed foods) or as processed/unhealthy (high in low-nutrient snacks, fast food, and low in fruit and vegetables)(Newby, 2007; Northstone et al., 2013). For example, findings of the ALSPAC study (n=8279) in the UK, identified three distinct clusters (processed, plant-based and traditional British) and three similar dietary patterns, using PCA from the dietary intakes of 7-year-old children. This suggests that both methods are useful and provide meaningful dietary patterns (Smithers et al., 2011).

Evidence from studies using *a posteriori* approaches have the advantage of not making prior assumptions of disease and health relationships, as they use existing dietary data to provide meaningful and interpretable dietary patterns across populations. However, these methods have some limitations (see, Table 3-4). For instance, dietary intake is culturally defined. Thus, because of the heterogeneity of reference populations, dietary patterns derived using these *a posteriori* methods are not reproducible. Also, these methods introduce subjective decisions when grouping food into food groups, or when selecting dietary patterns for final analyses (Jacques and Tucker, 2001).

Another, more recent, method of deriving dietary patterns is reduced rank regression, which uses both existing knowledge about disease aetiology (e.g. disease-related nutrients or biomarkers) and data-driven statistics to extract dietary patterns related to a specific disease outcome (Hoffmann et al., 2004; Michels and Schulze, 2005). Although reduced rank regression is similar to principal component analysis, it includes an extra step where intermediary/response variables commonly known to be associated with an outcome of interest are used to inform extracted dietary patterns. Therefore, this method requires existing evidence about factors related to the disease during the analysis of dietary data.

Although reduced rank regression and cluster analysis are useful methods of deriving dietary patterns (Emmett et al., 2015) the current research aimed to evaluate the usefulness of pre-defined diet scores and dietary pattern scores using PCA in assessing the relationship between dietary patterns and risk of obesity in preschool children in the UAE. Hence, a systematic review was carried out to investigate dietary patterns derived using these two approaches in preschool children and obesity risk.

Table 3-3 Dietary scores and indices used for preschool children

Dietary indices or scores	Country	Age group
Healthy Eating Index (HEI)	USA	> 2 years
Healthy Eating Index – 1995 (HEI – 2005)	USA	2 – 18 years
Children's Diet Quality Index	USA	>3 years
Variety Index for Toddlers	USA	Toddlers
Nutrient Rich Foods	USA	4 years - Adult
Food Variety (FV) score	USA	Children
Revised Children's Diet Quality Index	USA	2 – 18 years
Diet Quality Index for Preschool children	Belgium	2 – 6 years
Complementary Feeding Utility Index	England	Infant and toddlers
Healthy Nutrition Score for Kids and Youth	Germany	3 – 17 years
Indicator Food Index	Germany	Children and adolescents
Diet Quality Score	Germany	Children
Dietary Quality Score	Netherlands	Preschool
Preschool Diet-Lifestyle Index	Greece	2 – 5 years
Diet Quality Score	Scotland	2 – 5 years
Core Food Variety Score	Australia	Toddler
Fruit and Vegetable Variety Score	Australia	Toddlers
Diet Diversity Score	Bangladesh	<5 years
Dietary Diversity Score	Norway	> 13 months - Adult
Diet Diversity Index	Senegal	Infants and toddlers
Food Variety Index	Senegal	Infants and toddlers

Adapted from Marshall et al., 2014

Table 3-4 Strengths and Limitations of *a priori* and *a posteriori* methods of deriving dietary patterns

Strengths	Limitations
***a priori* approach**	
Based on scientific evidence	Based on current knowledge of diet and disease risk
Easily reproducible and comparable	Lack of consensus of 'healthy diet'
Good measure of adherence to guidelines and diet quality of population	Does not provide new information about diet and disease relationship
	Only focuses on selected aspects of the diet and therefore it may not describe overall dietary pattern
	Bias can be introduced when interpreting guidelines, constructing scores (e.g. choice of food to include) and defining cut-offs and setting scores
***a posteriori* approach**	
Reduces a large set of dietary variables into smaller number of factors while retaining variance from the original dataset	Relies on arbitrary decisions that can lead to bias (e.g. grouping food items, number of extracted components, rotation method used, naming of dietary patterns)
Allows the exploration undiscovered knowledge of relationships between diet and disease risk	Difficult to compare across populations as differences may be due to the method used to derive dietary patterns, rather than real differences
Allows specific patterns to be derived for population of interest	Extracted dietary patterns can be difficult to interpret or may not be meaningful

3.5 Dietary patterns and obesity risk in preschool children: a systematic review

3.5.1 Introduction

Many adult studies have examined associations between dietary patterns and obesity risk (Kant, 2004; Kourlaba and Panagiotakos, 2009), and suggest that unhealthy dietary patterns (high in sweets, processed meats, low quality foods and snacks) increase the risk of obesity (Newby and Tucker, 2004; Mikkilä et al., 2007; Waijers et al., 2007). However, much less is known about the relationship between dietary patterns and obesity risk in children, particularly in children under the age of 5 years (Smith et al., 2011; Ambrosini, 2014; Marshall et al., 2014; Okubo et al., 2015).

Although earlier reviews have summarised evidence of studies investigating dietary patterns in childhood and obesity (Lazarou and Newby, 2011; Smithers et al., 2011; Ambrosini, 2014; Marshall et al., 2014), these reviews underscore the scarcity of studies in preschool children. Smithers et al. (2011) identified 12 studies (12 out of 40 cross-sectional studies) that evaluated dietary patterns (using *a priori* and *posteriori* methods) in 1- to 5-year-old children, and investigated the associations with obesity, of which six were derived using diet scores, five were identified using principal component analysis, and one used cluster analysis. Another systematic review by Marshall et al. (2014) identified 26 studies (out of 119 studies) investigating associations of dietary patterns assessed using diet scores/indices and weight status in childhood (0-18 years old). However, only six of these studies were in preschool-aged children (Marshall et al., 2014).

Together, these reviews highlight that evidence for the relationship between dietary patterns and obesity risk in childhood is inconsistent, and research focused on preschool children is limited. Additionally, in light of the importance of identifying modifiable early dietary risk factors that may contribute to later obesity risk, these reviews also emphasised that further longitudinal studies are needed to investigate the association between early diet quality and later obesity risk (Togo et al., 2001; Smithers et al., 2011; Ambrosini, 2014).

To date, no review has solely focused on the influence of dietary patterns during the preschool period on obesity risk. The aim of the systematic review was to summarise and evaluate the current evidence investigating relationships between dietary patterns (derived from an *a priori* method using diet scores and an *a posteriori* method using principal component analysis) and obesity risk in preschool children from both cross-sectional and longitudinal studies. Although the focus of this thesis is on Emirati preschool children, findings from this review will provide a comprehensive understanding of the role of dietary patterns in the development of obesity among preschool children, and highlight a research gap in the Arabian Gulf region.

3.5.2 Methods

3.5.2.1 Search strategy

A systematic search of the electronic databases PubMed, MEDLINE and EMBASE was carried out to identify published articles describing dietary patterns and investigating associations between dietary patterns and preschool obesity between January 2010 and October 2016. This range was selected since Smithers et al. (2011) systematically reviewed studies up to January 2010.

The search strategy was developed using the Preferred Reporting Items for Systematic reviews and Meta-analysis (PRISMA) guidelines (Liberati et al., 2009). Studies that derived dietary patterns using diet scores or principal component analysis were included in the search strategy. Although, reduced rank regression and cluster analysis, are useful methods of deriving dietary patterns these were excluded because: (i) principal component analysis is the most commonly used method for deriving dietary patterns in young children (Smith et al., 2013); (ii) dietary patterns derived using principal component analysis have public health relevance since they are derived from dietary data collected from the population of interest, and therefore, describe the actual dietary pattern of the population; (iii) methodological differences between cluster analysis and principal component analysis would greatly limit comparability. For instance, dichotomous scores produced by cluster analysis cannot be adequately compared with continuous dietary pattern scores produced by principal component analysis (Ambrosini, 2014); and (iv) reduced rank regression uses both a priori and a posteriori approaches, and requires the use of intermediate/response variables related to the outcome (e.g. disease related nutrients/biomarkers), and therefore dietary patterns derived using this method may not reflect foods consumed together, compared to PCA-derived dietary patterns.

Search terms included those relating to methods used to derive dietary pattern descriptions: dietary pattern, eating pattern, dietary score, dietary index, food pattern, principal component analysis; or obesity outcomes: obesity, overweight, body mass index, adiposity, fat mass; or age group: preschool, children, childhood, toddler, kindergarten, child; and study type: cross-sectional, observational, prospective, longitudinal. An example search strategy using MEDLINE can be found in **Appendix D**. Reference lists of included studies were hand searched for studies not identified by the database searches. Experts in the field were also contacted to identify possible omissions.

3.5.2.2 Study selection

The systematic review was carried out using procedures described in the Cochrane Handbook of Systematic Reviews (Higgins and Green, 2011). Cross-sectional and prospective longitudinal studies investigating associations between dietary patterns during preschool and obesity risk were included.

3.5.2.3 Inclusion and exclusion criteria

Abstracts were screened and studies that met the inclusion and exclusion criteria described in Table 3-5 were included for full-text review.

Table 3-5 Inclusion and Exclusion criteria

Inclusion criteria
Published in English
Human studies
A measure of dietary patterns in preschool children aged between 2 and 6 years
A measurement of overweight or obesity in childhood
Exclusion criteria
Studies that did not report dietary pattern
Children were outside the included age range
Dietary patterns derived using reduced rank regression and cluster analysis

3.5.2.4 Data extraction

Titles and abstracts of articles were assessed for compliance with the inclusion criteria. A data extraction sheet, based on the Cochrane Consumers and Communications Review Group's template, was developed and refined to suit the research question (**Appendix B**).

Full-texts were reviewed and data were extracted from each study including: (i) characteristics of study design and participants; (ii) methods used to identify dietary patterns; (iii) outcome measures (including definition of obesity and assessment methods used); (iv) reported associations between dietary patterns and obesity.

3.5.2.5 Quality assessment

The methodological quality of prospective studies was assessed using a scoring tool devised by Ambrosini (2014) in a systematic review investigating associations between childhood dietary patterns and later obesity risk. The scoring tool was developed to assess study quality according to: (i) information, (ii) validity and (iii) precision in relation to the study population, study attrition, data collection methods and data analysis methods (Ambrosini, 2014) (see, Table 3-6).

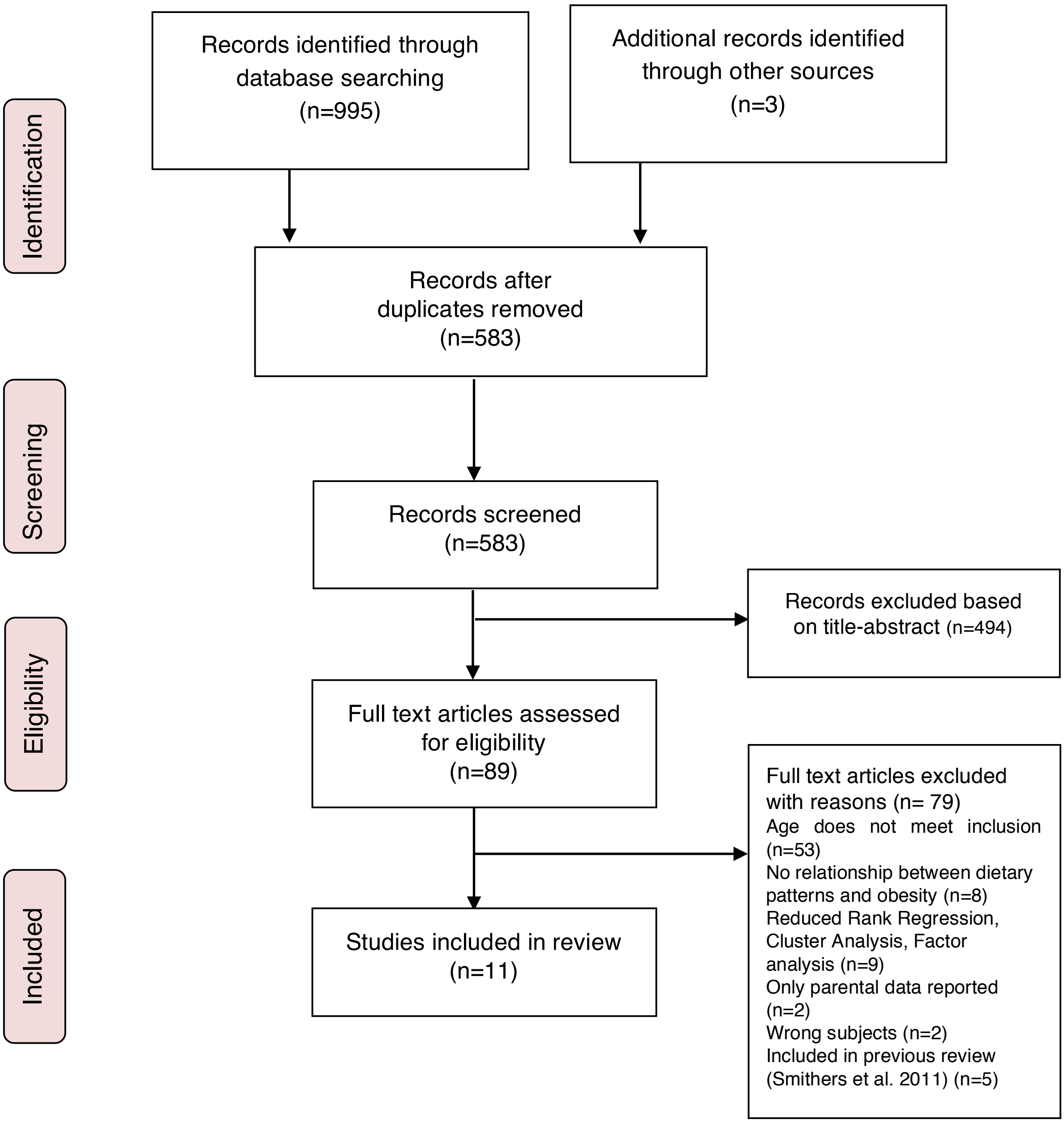
Studies were assessed against the scoring tool, based on twelve criteria. Each study was assigned either a positive score or negative score, depending on whether it met the quality criterion. Where a study did not provide sufficient information, and the decision was questionable a '?' was given. Scores were summed to reflect the overall quality, and a percentage was calculated. Two reviewers completed the data extraction and assessment of quality (myself and Dr Julie Lanigan). Discrepancies were resolved by discussion.

Table 3-6 Criteria for assessing methodological quality of studies

Study population and participation (baseline): the study sample represents the population of interest on key characteristics	
1. Adequate* description of sampling frame, recruitment methods, period of recruitment and place of recruitment (e.g. geographical location)	I
2. Participation rate at baseline at least 80%, or the non-response was non-selective (shows that baseline study sample does not significantly differ from population of eligible subjects).	V
3. Adequate* description of key characteristics of the baseline study sample (i.e. number of participants, age, gender and measured diet and anthropometry variables).	I
Study attrition: loss to follow-up is not associated with key characteristics (i.e. study participants adequately represent the study sample)	
4. Provision of exact number of participants at each follow-up measurement	I
5. Provision of exact information on follow-up duration	I
6. Response at long-term follow-up (>12 months) was at least 70% of the number of participants at baseline	V
7. Non-response during follow-up was non-selective (i.e. drop outs did not differ significantly from the study population in terms of key characteristics)	V/P
Data collection	
8. Measurement of dietary intake using quantitative method likely to represent usual dietary intake (i.e. at least 3-day diet record or an FFQ)	V
9. Measurement of weight status/overweight or obesity using objective measures (not self-reported)	V
Data analysis	
10. Appropriate statistical models were applied (i.e. multivariate regression models including more than one predictor variable)	V/P
11. The number of cases (i.e. overweight or obese) was at least ten times the number of independent variables	V/P
12. Point estimates and measures of their variability (i.e. confidence intervals or standard errors) are provided	I

Adapted from Ambrosini (2014), Criteria related to: Information (I), Validity (V), and Precision (P). * Sufficient information to repeat the study

Figure 3-1 Results of search strategy



3.5.3 Results

3.5.3.1 Study characteristics

Study characteristics are described in Tables 3-10 and 3-11, and include name of first author, year of publication, participant and study characteristics, exposures and assessment methods, definition and measurement of obesity, statistical analysis methods, and results.

Nine hundred and ninety-eight references were identified using the search strategy in **Appendix E**. Screening of abstracts and reference lists of included studies identified 89 potentially relevant articles (Figure 3-1). The main reason for exclusion was that the study did not include children in the age range. Eleven studies were included for full text review. The total number of children included was 28,483. More than half the studies included more than 1000 subjects (Manios et al., 2010; Meyerkort et al., 2012; Pala et al., 2013; Fernandez et al., 2016; Santos et al., 2016; Voortman et al., 2016).

There were five prospective (Table 3-10) and six cross-sectional studies (Table 3-11) eligible for review (see, Table 3-7). Included studies were from developed and developing countries: three from the US (Acharya et al., 2011; Laster et al., 2013; Fernandez et al., 2016), two from Brazil (Nobre et al., 2012; Santos et al., 2016), Greece (Manios et al., 2010; Leventakou et al., 2016), one each from the UK (Okubo et al., 2015), Australia (Meyerkort et al., 2012), and the Netherlands (Voortman et al., 2016), and one covering eight European countries (Sweden, Germany, Hungary, Italy, Spain, Belgium, Cyprus and Estonia) (Pala et al., 2013).

3.5.3.2 Dietary assessment methods

Four of the five prospective studies estimated dietary intake using semi-quantitative Food Frequency Questionnaires, and one used a 24-hour recall (Meyerkort et al., 2012) (Table 3-10). Of the six cross-sectional studies, three used Food Frequency Questionnaires alone. One used a 24-hour recall alone, and two combined the use of a 24-hour recall with a Food Frequency

Questionnaire (Acharya et al., 2011), and another with a food diary (Manios et al., 2010)(Table 3-11).

3.5.3.3 Diet scores/indices

Six studies used dietary scores/indices that assessed adherence to dietary guidelines or to a dietary pattern recognised to support health and reduced disease risk (Table 3-8). Most diet scores/indices assessed overall diet quality (Table 3-8) based on intake of foods or food groups (Acharya et al., 2011; Meyerkort et al., 2012; Fernandez et al., 2016; Voortman et al., 2016). One also used nutrient intakes (Laster et al., 2013), and another was developed using a prudent dietary pattern derived using PCA (Okubo et al., 2015).

3.5.3.4 Principal component analysis

Six studies used principal component analysis to derive dietary patterns (Manios et al., 2010; Nobre et al., 2012; Pala et al., 2013; Leventakou et al., 2016; Santos et al., 2016; Voortman et al., 2016). The number of foods/food groups entered into the PCA ranged from 12 (Manios et al., 2010) to 43 (Pala et al., 2013), and the number of dietary patterns derived ranged between one (Manios et al., 2010) and seven (Santos et al., 2016). Comparable dietary patterns were identified in each study. Most studies identified both ‘healthy’ and ‘unhealthy’ dietary patterns (Pala et al., 2013; Leventakou et al., 2016; Santos et al., 2016; Voortman et al., 2016), and one only identified a healthy dietary pattern (Manios et al., 2010) (Table 3-9).

The name used to label a dietary pattern was determined by investigators based on the factor loadings of foods that loaded highly on the pattern score. This was usually determined by examining scree plots or using eigenvalues (usually cut-offs above 2).

Although names (labels) given to identified dietary patterns differed between studies, ‘healthy’ or ‘unhealthy’ dietary patterns were comparable as they were characterised by similar foods. For instance, the ‘sweet and fat’ dietary pattern identified by Pala et al. (2013), and the ‘unhealthy’ dietary pattern identified by

Nobre et al. (2012) were both characterised by high factor loadings for sweet treats, chocolates, confectionery, soft drinks and sweetened beverages. Dietary patterns characterised by high factor loadings for fruits, vegetables, whole grain cereals, fish and seafood were commonly labelled as 'healthy', 'health conscious' or 'mediterranean' (Table 3-9). Other dietary patterns were influenced by traditional foods. For instance, Santos et al. (2016) identified a 'coffee and bread' pattern, characterised by bread, butter, coffee and sugar, which are commonly consumed in Brazil.

Table 3-7 Included studies categorised according to study type and method used to derive dietary patterns

	Study type		Total
	Cross-sectional	**Prospective**	
Principal component analysis	Manios et al., 2010 Nobre et al., 2012 Leventakou et al., 2016 Santos et al., 2016	Pala et al., 2013 Voortman et al., 2016 *	6
Diet score	Acharya et al., 2011 Laster et al., 2013	Meyerkort et al., 2012 Okubo et al., 2015 Fernandez et al., 2016 Voortman et al., 2016[a]	6
Total	6	5	

[a]used two approaches to derive dietary patterns

Table 3-8 Description of diet scores/indices included in the review

Score	Evaluation	Components	Scoring system
Diet Quality Score **Voortman et al., 2016**	Overall diet quality	Ten components: fruit, vegetables, bread and cereals, rice, pasta, potatoes and legumes, dairy, meat and eggs, fish, oils and fats, candy and snacks, and sugar sweetened beverages	Total score ranged from 0-10 on a continuous scale and was standardised to an energy intake of 1200kcal/d with the residual method. Cut off values for food intake were derived from recommendations of existing international guidelines. For each food group a ratio was calculated e.g. a child intake of 120g/day of fruit is divided by the recommended 150g/d to produce a ratio of 0.8. If a child exceeds the recommended intake, the score is truncated at 1. For candy and sugar sweetened beverages, intake above the maximum cut-off is assigned a 0, and assigned a proportional score between 0 and 1 if they consumed less than the cut-off. Scores range between 0-10, with a high score representing a healthier diet
Eating Assessment for Toddlers (EAT) score **Meyerkort et al., 2012**	Overall diet quality	Seven components: (1) whole grains, (2) vegetables, (3) fruit, (4) meat ratio, (5) dairy, (6) snack foods, (7) soda and drinks	Individuals assigned a score out of 10 for each component. Components 1-5 were defined as healthy for their nutritional benefits, and therefore greater consumption from these components resulted in scores closer to 10. Components 6 and 7 were defined as unhealthy (not recommended for young children), therefore greater consumption resulted in scores closer to 0. Overall score was determined from the sum of all 7 components, which ranged between 0 and 70.
Healthy Eating Index (HEI) **Laster et al., 2013**	Overall diet quality	10 components: grains, vegetables, fruits, milk, meat, total fat, saturated fat, total cholesterol, sodium and variety	Scoring between 0-100 (maximum score of 100). Points between 0-10 allocated for each component. Food component scoring is based on the number of servings in the US Food Guide Pyramid (Fat, sodium and cholesterol, are based on recommended cut-off points). Variety is based on the number of different foods: 3 different foods = 0, 3-8 different foods scored proportionally, >8 different foods given 10 points.

Table continued on next page

Score	Evaluation	Components	Scoring system
My Pyramid Food groups Acharya et al., 2011	Assessment of diet against US My Pyramid recommendations	Five components: fruit, vegetables, grains, dairy/milk, meat (or alternatives.	Dichotomous scoring (yes/no) for meeting recommendations. Number or % meeting recommended servings per day of each food component, according to the US My Pyramid Food Guide
Dietary Diversity Score Fernandez et al., 2016	Dietary diversity and variety	Five components: Vegetables, grains, protein, dairy and fruit)	The total percentage of children diet with the recommended food group proportions according to the Dietary Guidelines for Americans were calculated. Percentage of servings from five major food groups compared with age-specific recommended proportion of servings to obtain a percentage in relation to dietary guidelines for each food group ranging between 0 to 100%, which was multiplied by the Berry Index percentile to produce Dietary Diversity scores ranging between 0-100. Higher scores reflecting a more diverse diet.
Diet Quality Score Okubo et al., 2016	Overall diet quality	Compliance with prudent dietary pattern (derived from 51 food groups using PCA), characterised by frequent consumption of fruit, vegetables and fish.	Distribution of diet quality scores were categorised into thirds. Each child was assigned a value of 0, 1 or 2 according to where their diet score was in the distribution (0, lowest), (1, middle), (2, highest). These values were summed to yield a Diet Quality Index across early childhood, ranging from 0 (lowest diet quality) to 8 (highest diet quality).

Table 3-9 Description of dietary patterns derived using PCA

	No. of food group used	Derived dietary patterns
Manios et al., 2010	12	Healthy: total grains, vegetables, fruits, fish & seafood, legumes and oils
Nobre et al., 2012	24	Mixed: beef and pork, baked beans, milk and milk products, rice and roods, farinaceous, sweet and savoury biscuits, cakes, pastries, fruits, juices Snack: milk and milk products, sweet and savoury biscuits, fruits, juices, breads, margarine, toddy Unhealthy: fat snacks, sweet treats, artificial juices, soft drinks, sweets/desserts, stuffed cookies, fried or boiled eggs.
Pala et al., 2013	43	Snacking: hamburger, hot dog, kebab, falafel, butter or margarine on bread, savoury pies, chocolate and candy bars, bread (white) Sweet and Fat: chocolate or nut-spread on bread, cakes, puddings and cookies, candy and sweets (no chocolate), meat (fried), soft drinks (added sugar), mayonnaise, soft drinks (diet), cured meats and sausages Vegetable & Wholemeal: vegetables (raw), bread (wholemeal), vegetables (cooked), fruit (fresh), milk (no added sugar), milk (no added sugar), breakfast cereals (no added sugar), low fat butter or margarine on bread Protein & Water: fish (not fried), water, fish fingers (fried), eggs (not fried), meat (not fried), pasta and rice, pizza
Voortman et al., 2016	21	Health conscious; pasta and rice, fruit, vegetables, potatoes, vegetable oils, fish, meal, legumes Western-like: refined cereals, soups and sauces, savoury snacks, confectionery, other fats, meat, sugar-containing beverages.
Leventakou et al., 2016	14	Mediterranean: pulses, olive oil, vegetables, fish and seafood, fruits Snacky: potatoes and other starchy roots, salty snacks, sugar preserves and confectionery, eggs Western: cereals and cereal products, cheese, total added lipids, non-alcoholic beverages, meat and meat products
Santos et al., 2016	22	Fruits & Vegetables: lettuce, tomato, carrot, beets, cabbage, broccoli, orange, banana, apple, papaya, mandarin, pear, fresh fruit juice Snacks & Treats: candies, chocolate, ice-cream, jelly, jam, regular and diet soft drinks/juice, chips Coffee & Bread: bread, butter, margarine, mayonnaise, sugar, coffee Milk: milk/yoghurt, chocolate milk powder Cheese & processed meats: cheese, slice meats (ham, mortadella, sausage) Rice & Beans: rice, beans Carbohydrates: pasta, potatoes

3.5.4 Dietary pattern or dietary scores/indices and obesity

All included studies investigated associations between dietary patterns and obesity-related outcomes (concurrently or prospectively). Almost all studies used BMI or BMI standard deviation scores (BMI z-scores) to define overweight and obesity, either by using BMI as a continuous variable or as a dichotomous variable using cut-offs relative to a specific population or international reference data (Tables 3-10 and 3-11).

Four used the CDC growth charts (Manios et al., 2010; Acharya et al., 2011; Laster et al., 2013; Fernandez et al., 2016), two studies used WHO 2007 growth references (Nobre et al., 2012; Santos et al., 2016), one used the International Obesity Task force reference (Leventakou et al., 2016), and two studies used BMI as a continuous variable (Meyerkort et al., 2012; Okubo et al., 2015). Additionally, two studies measured fat-free mass and fat mass to reflect adiposity using the Dual Energy X-ray Absorptiometry (DEXA) (Okubo et al., 2015; Voortman et al., 2016).

3.5.4.1 Diet scores/indices and obesity

3.5.4.1.1 Prospective studies

One study found an association between low diet quality and later obesity risk (Okubo et al., 2015). Okubo et al. (2015) found that a poor diet quality at 3 years was associated with a higher fat mass at 6 years, when comparing the lowest and highest diet quality index (β= 0.23; 95% CI: 0.01 to 0.45). This association remained after adjusting for confounding factors. However, no associations were found between diet quality and BMI at 6 years of age (Okubo et al., 2015).

Voortman et al. (2016) found that children in the highest quartile for a healthy diet score at the age of 1 had a higher fat free mass index at 6 years of age, compared to children in the lowest quartile (β= 0.19; 95%CI: 0.08 to 0.30). No differences in fat mass were reported. The two remaining prospective studies, (Meyerkort et al., 2012; Fernandez et al., 2016) found no association between diet scores and obesity risk at various follow-up points (Table 3-10).

3.5.4.1.2 Cross-sectional studies

An association between diet scores/indices and obesity was reported in one cross-sectional study. Acharya et al. (2011) assessed dietary quality according to My Pyramid food groups, and found that a higher consumption of fruit (servings per week) was associated with a 21% lower risk of overweight and obesity. However, greater consumption of low fat dairy and unsweetened beverages (servings per week), were associated with a higher risk of obesity (for low fat dairy: adjusted OR= 0.79; 95% CI: 0.62 to 1.01; for unsweetened beverages: adjusted OR=1.49 95% CI: 1.12 to 1.99) (Acharya et al., 2011). However, Laster et al. (2013), who investigated diet quality using the Healthy Eating Index, did not find associations between overall diet quality and obesity (Table 3-11).

3.5.4.2 Dietary patterns derived using a PCA and obesity

3.5.4.2.1 Prospective studies

One prospective study that used PCA to derive dietary patterns found an association with later obesity risk. Pala et al. (2013) found that children in the highest vegetables and wholemeal tertile had a lower risk of becoming overweight/obese, compared to those in the lowest tertile (OR= 0.69; 95% CI: 0.54 to 0.88). Voortman et al. (2016) identified two dietary patterns: a 'health conscious' pattern and a 'Western like' pattern, and reported that higher adherence to the 'health conscious' pattern at the age of 1 was associated with greater fat-free mass at 6 years of age, when comparing the lowest and highest quartile (β= 0.17; 95% CI: 0.06 to 0.29) per standard deviation score increase in diet score. No associations were found with fat mass (Voortman et al., 2016) (Table 3-10).

3.5.4.2.2 Cross-sectional studies

Three cross-sectional studies that used PCA to derive dietary patterns found no association with obesity related outcomes (Manios et al., 2010; Nobre et al., 2012; Leventakou et al., 2016). However, one study reported several associations with the different dietary patterns identified (Santos et al., 2016). Santos et al. (2016) found that obese 6-year-old children (n=3,427) had lower scores on the snacks and treats pattern (β= -0.07; 95% CI: -0.14 to -0.01), fruits and vegetables pattern (β= -0.07; 95% CI: -0.18 to 0.00), carbohydrate pattern (β= -0.02; 95% CI: -0.20 to -0.00), and coffee and bread pattern (β= -0.11; 95% CI: -0.19 to -0.02). Obese children also scored higher on the cheese and processed meats pattern compared to non-obese children (β= 0.13; 95% CI: 0.04 to 0.23) (Santos et al., 2016) (Table 3-11).

3.5.5 Quality assessment

The methodological quality of prospective studies was assessed using the quality assessment tool previously used by Ambrosini (2014). The scores ranged from 58% to 75%. Two studies were ranked as high quality, with a quality score greater than 70% (Pala et al., 2013; Fernandez et al., 2016). The remaining studies were moderate quality. All studies met the criteria for adequate description of study sample, appropriate statistical analysis and measures of variability. All studies adjusted for potential confounders known to influence dietary assessment, including age, sex, birth weight, socioeconomic status, maternal education, physical activity and energy intake (Tables 3-10 and 3-11).

All studies used appropriate methods to assess overweight/obesity and dietary intake. Medium-quality studies did not meet the criteria for participation rate, or non-selective response (Table 3-12).

3.5.6 Discussion

This systematic review aimed to update a previously published systematic review investigating associations of dietary patterns with the risk of obesity in preschool children (Smithers et al., 2011). Therefore, this current review summarises and appraises recent evidence of associations between dietary patterns and obesity risk from both cross-sectional and prospective studies. The review identified five prospective studies, of which four used dietary scores/indices and two used PCA to derive dietary patterns during preschool and examined associations with later obesity risk. However, not all studies found an association with obesity related outcomes (Meyerkort et al., 2012; Fernandez et al., 2016).

One prospective study that used PCA to derive dietary patterns revealed that a 'healthful' dietary pattern at preschool reduced the risk of developing obesity in childhood (Pala et al., 2013). Pala et al. (2013) found that a 'healthier' dietary pattern characterised by high intake of fruits, vegetables, wholemeal bread and whole grain cereals reduced the risk of obesity after two-year follow-up. Similarly, only one study found an association between the quality of preschool children's diet and later obesity risk. Okubo et al. (2015) reported an inverse association between diet quality score and later fat mass, suggesting that a lower quality diet characterised by high intake of high in energy dense, low-fibre, high fat foods (i.e. poor diet quality) increased the risk of later obesity risk.

On the other hand, Voortman et al. (2016) who used two approaches to derive dietary patterns, found that children in the highest quartile of a 'health conscious' dietary pattern and diet quality score at 1 year of age had higher fat free mass at 6 years of age, but not fat mass. Although this study did not demonstrate that a healthier dietary pattern reduced the risk of obesity, the increase in fat free mass, but not fat mass, could suggest that a healthy dietary pattern favours a leaner body composition, which has been suggested to confer health benefits and is associated with improved cardiovascular health (Lang et al., 2015).

The present review agreed with earlier reviews, which found that associations between dietary patterns and preschool obesity were inconsistent (Smithers et al., 2011; Ambrosini, 2014; Marshall et al., 2014). Three of the four studies that used PCA showed no association between dietary patterns and obesity-related outcomes (Manios et al., 2010; Nobre et al., 2012; Laster et al., 2013; Leventakou et al., 2016). Santos et al. (2016) found that while obese children had a lower consumption of fruit and vegetables; they also scored lower on snacks and treats pattern. Only one of the two studies that investigated diet scores found an association with obesity. Although Acharya et al. (2011) reported an inverse association between fruit consumption and obesity risk, the same study also found that the risk of obesity was highest amongst those consuming low fat dairy and unsweetened beverages.

Given the cross-sectional design of these studies, one possible explanation for these findings could be that parents of obese children are aware of their child's weight status and therefore underestimate their child's food consumption (Santos et al., 2016), or they attempt to reduce their child's weight by offering low fat/sugar alternatives (Acharya et al., 2011). Moreover, although some cross-sectional studies found associations between 'healthy/high quality' diet score and obesity risk, causality cannot be established (Heitmann and Lissner, 1995; Kleiser et al., 2009).

These conflicting findings of associations between dietary patterns and obesity risk in children are similar to findings from earlier systematic reviews investigating such associations in children (Smithers et al., 2011; Ambrosini, 2014; Marshall et al., 2014), and highlight the need for studies that aim to assess longitudinal associations of dietary patterns or scores during early childhood and obesity-related outcomes in later life.

3.5.6.1 Strengths and Limitations

The present systematic review investigated associations between the dietary patterns, and dietary scores, of preschool children and obesity related outcomes, both concurrently and prospectively.

Overall, the review provides updated evidence from medium to high quality prospective studies. However, several limitations within the existing research need to be taken into consideration. Most clearly, the heterogeneity of studies makes it a challenge to combine and compare findings in a cohesive manner. One major challenge was comparing the different obesity-related outcomes reported. Most studies used cut-offs for BMI or BMI z-scores to define overweight/obesity. However, the use of different reference data with respect to the study population, and different methods used to calculate excess adiposity/percentage body fat between studies also complicated comparisons (see Chapter 1, section 1.4).

The absence of relationships, and the inconsistent associations between dietary patterns and obesity risk could also be explained by limitations of dietary assessment methods (see section 3.2), different dietary components extracted, or dietary scores/indices used, different anthropometric measures used to estimate obesity (see section 1.4), and small sample size of included studies

While some dietary patterns derived using PCA were comparable, the type and number of food groups chosen prior to analysis can impact the identified dietary pattern, and only reflect the dietary habits of the study population (Hoffmann et al., 2004; Nettleton et al., 2007). Therefore, this limits their reproducibility and comparability with other populations. For example, in this review the range of food groups used in studies varied between 12 (Manios et al., 2010) and 43 (Pala et al., 2013).

Another limitation of the current review is the exclusion of other methods of deriving dietary patterns (e.g. reduced rank regression and/or cluster analysis). The inclusion of approaches to derive dietary patterns other than PCA and diet scores may have provided useful insights into associations that may exist between dietary patterns derived using other methods (e.g. reduced rank regression) and obesity risk in preschool children. However, since PCA is the most commonly used method of deriving dietary patterns in young children, this approach was chosen.

Overall, dietary scores are considered useful when assessing overall diet quality, because they allow the summation of dietary intake into a single measure to compare diet quality between groups. However, the methodological differences in developing dietary scores/indices also limit their comparability (see, Table 3-4). For example, dietary scores that are dichotomised into ‘good’ or ‘low’ quality may introduce selective bias, and exclude the full range of foods consumed. Therefore, using dietary scores as a continuous variable has been recommended to better represent diet quality (Waijers et al., 2007). As discussed in section 3.4.1, the development of dietary scores is dependent on dietary recommendations or current knowledge of foods/food groups known to prevent disease. However, diet scores are not predictive of a specific disease (e.g. obesity risk), and may only represent dietary guidelines for specific populations. Therefore, associations must be interpreted with caution (Marshall et al., 2014).

Moreover, methodological issues in the study design, sample size, study attrition, and method of assessing dietary intake could influence the study quality and findings. Most of the included studies used FFQ to assess habitual dietary intake. Others used 3-day food diaries or 24-hour recall, which can only provide data on intake during a limited period, so could possibly exclude foods. Thus, limitations of dietary assessment methods and common sources of error (under/over reporting) need to be taken into consideration when interpreting results (see section 3.2.3).

Lastly, it is important to take into account that children undergo periods of growth and development, which may influence their energy intake. Some of the reviewed studies adjusted for energy intake and other potential confounding factors that are known to be influence obesity risk (e.g. physical activity, sedentary behaviour). However, as previously mentioned, obesity risk factors are multifactorial (see section 2.1) and could change with age. For instance, older children may have greater access to energy dense foods, or consume foods outside their parents' supervision. Hence, an array of influential social and environmental exposures should be considered in order to better understand the relationship between dietary patterns and obesity risk.

3.5.7 Conclusion

Although some studies included in this review suggest that dietary patterns or dietary scores characterised by low nutrient, energy dense foods may predispose preschool children to overweight and obesity, concurrently or in later life, the evidence remains inconsistent. Also, while cross-sectional studies predominate in the literature, these findings cannot reliably imply causal inferences. More prospective research is needed to explore the longitudinal influences between dietary scores or dietary patterns in preschool children and later obesity risk.

Nevertheless, this systematic review provides valuable insight into associations between dietary patterns, derived using two methods and preschool obesity. Hence, for the purpose of this thesis, both an *a priori* (dietary scores) and an *a posteriori* approach using principal component analysis will be used to identify dietary patterns of preschool children in the UAE and investigate associations of these with obesity.

3.6 Chapter summary

Although dietary intake is variable and difficult to measure, evidence suggests that nutrition, in particular high protein intake in preschool children, is an important risk factor of obesity. In contrast, dietary patterns take into consideration the correlated nature of the human diet and, therefore, capture the whole diet of individuals. Using food-based evidence could be more helpful and can be used to develop guidelines for foods that are negatively associated with disease risk (e.g. obesity). However, there is currently no consistent evidence for an association between dietary patterns and obesity in preschool children, especially in the UAE.

Table 3-10 Prospective studies investigating dietary patterns or scores in preschool children and later obesity risk

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Meyerkort et al., 2012 **Australia**	Prospective longitudinal study: Raine Study n=2868 aged between 1 and 3 years	Dietary data collected using 24-hr recall at 1, 2 and 3 years Diet Quality using Raine Eating Assessment Tool (EAT) score	Calculated BMI (kg/m^2) at 3, 4, 5, 8, 10, 14, 17 years of age.	Multivariable linear regression to investigate association between diet quality at 1, 2 and 3 years of age and BMI Adjusted for Age, birth weight, maternal smoking, socioeconomic status, family size, maternal smoking, maternal age, maternal tertiary education	Median of EAT score was moderate at (boys: 41.7, girls: 41.7) 2 (boys: 38.3, girls: 40.0) and 3 (boys: 36.7, girls: 38.3) years of age. No association between diet quality score at 1, 2 and 3 years of age and BMI at later follow-up.
Pala et al., 2013 **Europe**	Prospective study: Europe Identification and Prevention of Dietary and Lifestyle induced health effects in Children and Infants (IDEFICS) n= 14989 children aged 2-9 years (mean age: 6 years)	Dietary data collected using Children's Eating Habits Questionnaire FFQ Derived Dietary patterns from 43 food groups using PCA	Overweight and Obesity defined using BMI-for-age and sex-specific z-scores according IOTF criteria at 2-year follow-up.	Mixed-effects logistic regression models investigates association between dietary patterns and subsequent risk of overweight and obesity Adjusted for age, sex, baseline BMI, effect of country, physical activity (hrs/week), level of income (based on country).	Derived four dietary patterns (1) snacking, (2) sweet and fat (3) vegetables and wholemeal (4) protein and water Children in the highest vegetables and wholemeal tertile had a lower risk of overweight/obese (OR: 0.69, 95% CI: 0.54–0.88) (p=0.003) at 2-year follow-up (n=9427)

Table continued on next pages

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Okubo et al., 2015 **UK**	Prospective study: Southampton Women's Study n=700 children 3 of age	Dietary data collected using 80 food item FFQ (age-specific validated) Developed Diet Quality Score (DQS) from Prudent dietary pattern coefficients (Derived from 51 food groups using PCA)	Body composition assessed using Dual-energy X-ray absorptiometry (DEXA) and BMI calculated at 6 years of age.	Multiple linear regression examined associations between diet quality at 3 years of age and fat mass/BMI at 6 years of age. Adjusted for maternal pre-pregnancy BMI, smoking status in pregnancy, maternal vitamin D in later pregnancy, duration of breastfeeding, time moving each day and time spent watching TV at 4 years	10.5% of children had the lowest diet quality (DQI=0), 33.3% had a DQI between 1 and 3, 37.1% had a DQI between 4 and 6, and 19.1% had a high diet quality (DQI=7-8). Inverse association between DQS at 3 years of age and fat mass at 6 years (β 0.23 (95% CI 0.01,0.45) ($p=0.01$) No association between DQS at 3 years and BMI at 6 years
Fernandez et al., 2016 **USA**	Prospective study: Head Start program n= 340 children Mean age 4.2 (0.5) and follow-up (20.6 months) mean age 6 (0.7) years	Dietary data collected using Harvard service FFQ at baseline. Created Overall variety score and Dietary Diversity score	At mean age 6 (0.7) years overweight and obesity defined using BMI-for-age and sex specific CDC growth charts	Multivariable linear regression to examine the association between dietary variety, and dietary diversity scores with children's BMI score at follow-up Adjusted for gender, age, daily energy intake, primary caregiver education, race/ethnicity, BMI, household food security, baseline BMI z-score, mean follow-up period.	For overall variety mean (SD) was 35.4(9.3) for boys and 36.0 (9.6) for girls. For dietary diversity mean (SD) was 45.3 (16.2) for boys and 47.9 (15.3) for girls. No significant association between diet scores and prospective BMI z score (n=264)

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Voortman et al., 2016 **Netherland**	Prospective study: Generation R study n=1980 at 1 and 6 years of age	Dietary data collected using 211 food item FFQ at 1 year Used two approaches: (1) *a priori* diet quality score (2) derived dietary patterns from 21 food groups using PCA	Fat mass assessed using Dual-energy X-ray absorptiometry (DEXA) to calculate Fat mass index, Fat-free mass at 6 years of age	Multivariable linear regression examined associations between dietary patterns and diet scores at 1 year of age and body composition at 6 years of age. Adjusted for maternal age, BMI at enrolment, supplement use, education, household income, introduction of solids, breastfeeding and energy intake at 1 year and television viewing at 2 years	Mean (SD) diet quality score at the age of 1 year was 4.2 (±1.3) Two dietary patterns using PCA: (1) health conscious (2) Western like PCA derived 'health conscious' dietary pattern (β 0.17 (95%CI 0.06-0.29) and higher diet quality score (β 0.19 (95%CI 0.08-0.30) at the age of 1 was associated with a higher fat free mass index at 6 years of age when comparing (Q4 vs. Q1) but not fat mass.

Table 3-11 Cross-sectional studies investigating dietary patterns or scores in preschool children and obesity risk

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Manios et al., 2010 **Greece**	Cross-sectional study Growth, Exercise and Nutritional Epidemiological Study in PreSchoolers (GENESIS) study 2317 children aged 2-5 years	Dietary intake collected using 24-hour recall (1 weekend) and food diaries (2 weekdays) Derived dietary patterns from 12 food groups using PCA	Overweight and obesity defined using BMI-for-age and sex specific CDC growth charts	Logistic regression analysis between dietary pattern scores and probability of obesity Adjusted for age, sex, energy intake, maternal education, smoking, birth weight, parental BMI, physical activity, television viewing and child feeding pattern from (birth-6 months)	PCA derived one dietary pattern: Healthy No significant association found between dietary pattern and obesity.
Acharya et al., 2011 **USA**	Cross-sectional study Head start program 770 children aged 3-5 years	Dietary intake collected using Nutrition Data System for Research 24-hour recall and Block child FFQ Calculated food groups according to My Pyramid food groups	Overweight and obesity defined using BMI-for-age and sex specific CDC growth charts	Step wise linear regression assessed associations between food group intake and obesity	The risk of obesity was lower for fruit intake (OR: 0.79 95% CI 0.62-1.01), and higher for low fat dairy intake (OR 2.93 95% CI 1.46-6.05) and unsweetened beverages (OR 1.49 95% CI 1.12-1.99)

Table continued on next pages

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Nobre et al., 2012 **Brazil**	Cross-sectional study 232 preschool children aged 5 years.	Dietary intake collected using FFQ (developed by Sales et al. 2006) Derived dietary patterns from 24 food groups using PCA	Overweight and obesity defined using WHO BMI z-score cut-offs	Logistic regression examined the association between dietary patterns and BMI z-score Adjusted for child's time in school, excessive maternal weight, maternal work outside the household and income per capita	Three dietary patterns (1) Mixed diet, (2) Snack, (3) Unhealthy No significant association between child BMI and dietary patterns
Laster et al., 2013 **US**	Cross-sectional study Kids and Adults Now-Defeat Obesity (KAN-DO) study. Part of the randomised controlled trial 177 children aged 2-5 years	Dietary intake collected using 24-hour recall. Diet quality calculated using Healthy Eating Index (HEI-2005).	Overweight and obesity defined using BMI-for-age and sex specific CDC growth charts	Examined correlations between HEI and BMI z-score using Pearson's correlation Adjusted for child breastfeeding exposure, mother's race, education, household income, marital status, smoking status, and current breastfeeding status	Thee mean (SD) of HEI-2005 scores were 67.6 (9.9). Only 11% of children had Healthy Eating Index-2005 scores greater than 80 No significant correlation found between HEI and BMI z-score

Authors & Country	Study and Subject characteristics	Exposures and assessment methods	Definition and measurement of obesity	Analysis	Results
Leventakou et al., 2016 **Crete, Greece**	Cross-sectional study Rhea' birth cohort study 683 (52% boys) 4-year-old children	Dietary intake collected using 'Rhea Follow-up' 118 food item FFQ' Derived dietary patterns from 14 food groups using PCA	Overweight and obesity defined using the IOTF references	Multiple linear regression models were examined the association between dietary patterns and obesity risk.	Three dietary patterns (1) Mediterranean (2) Snacky, (3) Western No significant association was found between dietary patterns and BMI z-score
Santos et al., 2016 **Brazil**	Cross-sectional study 2004 Pelotas birth cohort study 3,427 (%) 6-year-old children	Dietary data collected using 54 food item FFQ' Derived dietary patterns from 22 food groups using PCA	Overweight and obesity defined using WHO 2007 BMI z-score cut offs	Multiple linear regression models were used to determine the association between dietary patterns and BMI status Adjusted for Social class, mothers age at birth, child sex, skin colour, exclusive breastfeeding duration, and daily energy intake	Seven dietary patterns (1) Fruits and vegetables (2) snack and treats, (3) Coffee and bread (4) Milk (5) Cheese and processed meats (6) Rice and beans (7) Carbohydrates Obese children presented lower intake of snacks and treats (β= -0.07, 95% CI: -0.14, -0.01), fruits and vegetables (β= -0.07, 95% CI: -0.18, 0.00), carbohydrates (β= -0.02, 95% CI: -0.20, -0.00), and coffee and bread (β= -0.11, 95% CI: -0.19, -0.02), and higher intake of cheese and processed meats (β= 0.13, 95% CI: 0.04, 0.23) compared to non-obese children.

Table 3-12 Quality assessment of prospective studies

	1	2	3	4	5	6	7	8	9	10	11	12	% Met criteria
1. Meyerkort et al., 2012	+	-	+	+	-	-	-	+	+	+	+	+	67
2. Pala et al., 2013	+	+	+	+	?	-	?	+	+	+	+	+	75
3. Okubo et al., 2015	+	-	+	-	?	?	+	+	+	+	?	+	58
4. Fernandez et al., 2016	+	-	+	+	+	+	-	+	+	+	?	+	75
5. Voortman et al., 2016	+	-	+	+	+	+	-	-	+	+	?	+	67

Chapter 4 Interventions to prevent preschool obesity

Tell me and I forget. Teach me and I remember. Involve me and I learn - Benjamin Franklin

4.1 Introduction

As reviewed in earlier chapters, preschool obesity is a major public health issue (de Onis et al., 2010; Ng et al., 2014), with long-lasting health consequences (Pulgarón, 2013)(see section 1.8). Obese children are found to gain most of their excess weight before the age of 5 (Gardner et al., 2009), and are at a higher risk of becoming obese adults (Simmonds et al., 2015). Moreover, obesity promoting behaviours such as high consumption of energy dense food, increased sedentary behaviour, reduced physical activity and shorter sleep established during the preschool period are likely to persist into adulthood, and increase the risk of obesity (Birch and Fisher, 1998; Reilly, 2008; Monasta et al., 2010; te Velde et al., 2012; Campbell et al., 2013; Woo Baidal et al., 2016) (see section 2.3).

Once obesity is established, weight loss is difficult and costly (Dehghan et al., 2005). However, preschool children are more responsive to the control of parents/caregivers, and their behaviours are more malleable than in later life (Goldfield et al., 2012; Skouteris et al., 2012). Also, since prevention strategies that target children under the age of 5 years are found to be more successful and cost-effective compared to those carried out in older children (> 5 years of age) (Reinehr et al., 2010; Cheng et al., 2014), there is a growing consensus that the preschool years could be a critical period to intervene in order to prevent the risk of developing obesity (Campbell and Hesketh, 2007; Birch and Ventura, 2009; World Health Organisation, 2014; Lobstein et al., 2015).

Prevention of overweight and obesity in early life is therefore a public health priority (National Institute for Health and Care Excellence, 2006; World Health Organisation, 2016). For example, consistent with previous reports supporting a whole-system approach to tackling obesity (Butland et al., 2007)(Figure 4-1), the recent WHO (2016) 'Ending Childhood Obesity' commission stressed the importance of prevention by targeting one or a combination of modifiable childhood obesity risk factors at various levels (e.g. individual, environmental, societal) and settings (e.g. family/home, school, community), and emphasised the importance of using behavioural strategies together with environmental, community and policy approaches. (World Health Organisation, 2016).

This chapter aims to: (i) overview intervention approaches aiming to prevent preschool obesity, (ii) review evidence on preschool obesity prevention interventions from systematic reviews and meta-analyses; (iii) explore simple educational (minimal) interventions, focusing on those targeting parents; (iv) address the research gap in the UAE and neighbouring countries in relation to preschool overweight and obesity prevention; and (v) propose a rationale for the use of a simple educational intervention in the UAE.

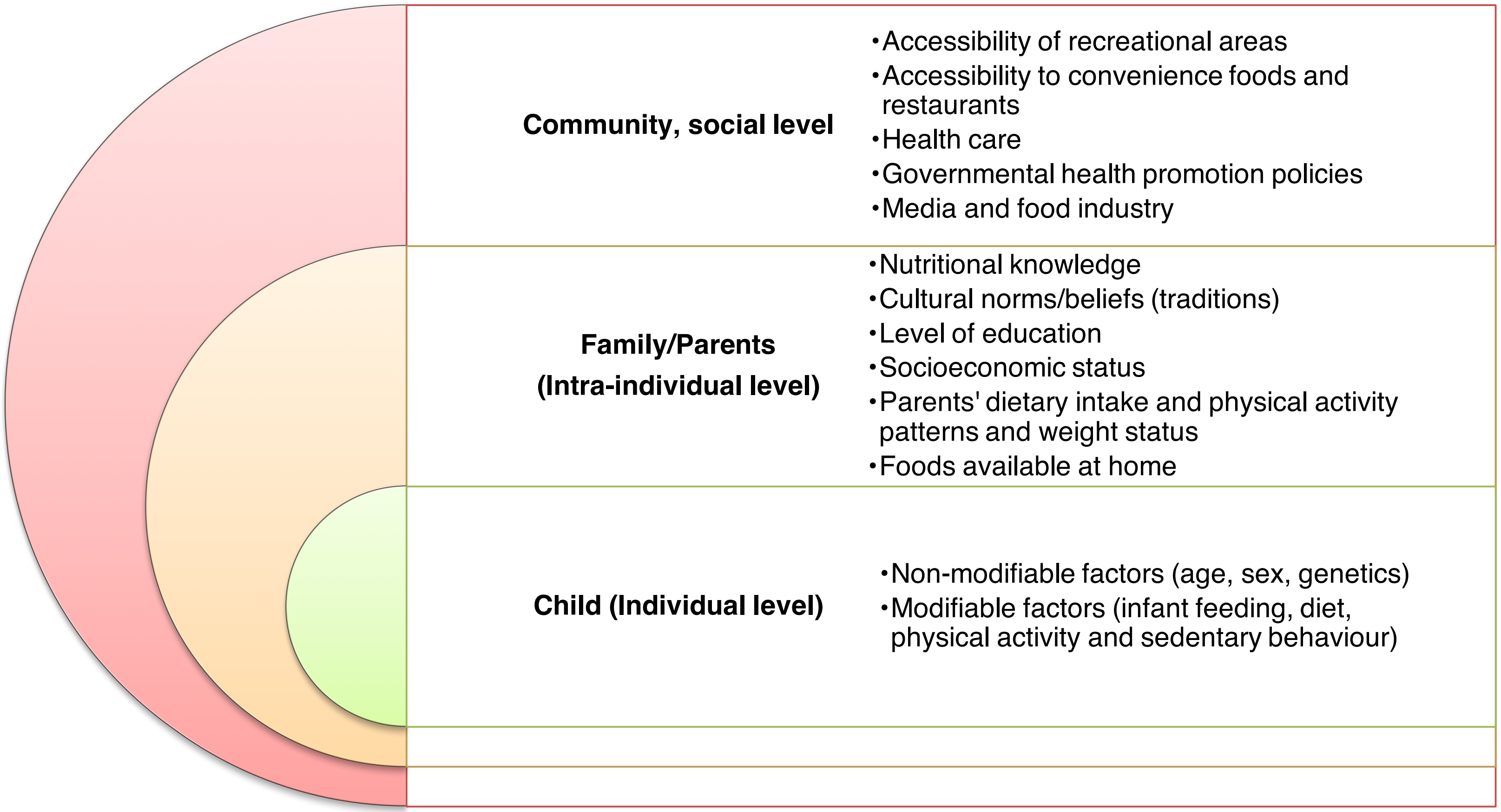


Figure 4-1 Whole-system approach for the prevention of preschool obesity

4.2 Overview of intervention approaches aiming to prevent preschool obesity

Obesity prevention interventions aim to maintain a healthy weight, and prevent excess weight gain in children, but most importantly do not aim to promote weight loss. There is currently a wealth of recommendations and strategies for the design of obesity prevention interventions (National Institute for Health and Care Excellence, 2006; World Health Organisation, 2016). While, most interventions have focused on dietary intake modification and physical activity promotion, others have also targeted other modifiable risk factors previously found to promote obesity-related behaviours and increase obesity risk (e.g. screen time, intake of sugary drinks, unhealthy/processed foods, and inadequate sleep) (Brown and Summerbell, 2009; Wang et al., 2015). However, these interventions vary in relation to the complexity of approaches used to bring about change. Intervention approaches broadly include; educational, behavioural, and health promotion strategies, but more specifically may use written materials sent home, behaviour change strategies, interactive physical activity, and nutrition education. Other approaches may also include: parental skill development, goal setting, motivational interviewing, and hands-on food preparation (Birch and Ventura, 2008; Waters et al., 2011).

These approaches also vary in relation to the use of theoretical underpinning for behaviour change (e.g. social cognitive theory) (Glanz et al., 2008), targeted behaviours/components (e.g. targeting both exercise and diet, or alone), involvement of parents (e.g. actively or passively), complexity/intensity of interventions (e.g. duration and number of sessions per week) and settings (school, community, and/or home) (Waters et al., 2011; Ling et al., 2016).

4.2.1 School-based interventions

School-based interventions refer to those implemented in preschools, child/day-care centres, and nurseries, and are mostly delivered by teachers or external educators (Wang et al., 2015). Since the majority of children from a wide range of social groups attend school/day-cares, most obesity prevention interventions have been carried out in the school-setting (Lobstein, 2006; Campbell and Hesketh, 2007; Wang et al. 2015; Ling et al., 2017). However, conducting research in the school environment is found to be challenging because; (i) school-based interventions rely on the motivation and skills of trained teachers or educators to deliver programs within classrooms. Therefore, in the case that some teachers lack the necessary skills to carry out interventions, the effectiveness of such interventions may be compromised. (ii) The lack of joint effort between the home (parental support) and school to influence obesity-related behaviours (e.g. screen time, intake of sugary foods/drinks, physical activity level, unhealthy foods), disregards the importance of the home environment and parents in influencing diet and physical activity habits (Health et al. 2007, Alexander et al. 2010).

Several studies have shown some promise for school-based interventions in preventing preschool obesity (2 – 5 year old children), particularly if they involved parents (Eliakim et al., 2007; Fitzgibbon et al., 2005; Nemet et al., 2013; Zask et al., 2012). However, not all have been effective in reducing behaviours that contribute to obesity, or reduced BMI z-score compared to controls (Reilly et al., 2006; Dennison et al., 2004; De Bock et al., 2012; Bellows et al., 2013).

The method of delivering the intervention and the target population can both influence outcomes, and therefore need to be taken into consideration (Ling et al. 2016). For instance, in the Hip Hop to Health Jr. intervention that targeted dietary and physical activity habits, and included a behavioural theoretical framework (social cognitive theory). A total of 362 children (aged 3-5 years) were randomised to either intervention (six centres) or control (six centres) for 14 weeks. The intervention involved 20 minutes of healthy eating and physical activity education and 20 minutes of active exercise, delivered three times a week by trained early childhood educators. Parents received 12 weekly newsletters with information to promote healthy eating and physical activity, and homework assignments during the intervention period. The control group received one 20-minute lesson on general health each week, and parents were provided with information without a homework assignment.

Following adjustment for age and baseline BMI, the intervention children (n=197) were found to have a smaller increase in BMI compared to the control group (n=212) at the 1 year follow-up (mean difference in BMI (kg/m^2)= -0.53; 95% CI: -0.91 to 0.14; p=0.01) and 2 year follow-up (mean difference in BMI (kg/m^2)= -0.54; 95% CI: -0.98 to 0.10; p=0.02) (Fitzgibbon et al., 2005).

However, although the Hip Hop to Health Jr trial reduced weight at 1 year and 2 year follow-up, in a mostly African American population of low income preschool children (99% of the study population) (Fitzgibbon et al. 2005), the intervention was ineffective in a mostly Hispanic population of preschool children (Fitzgibbon et al. 2006). Similarly, the one-year evaluation of the teacher-delivered (Hip-Hop to Health Jr) intervention did not have an effect on BMI z-score (Kong et al. 2016). These differences therefore highlight that factors outside and within the school setting (e.g. food availability at home, parental influences, ethnic background, cultural factors, accessibility to healthy food choices in school canteens) may influence dietary intake, physical activity, sedentary behaviours, and ultimately obesity risk.

4.2.2 Community-based interventions

Community-based interventions, are most often conducted in community centres, churches and primary care clinics, and primarily focus on targeting both children and parents. Although, in recent years the number of childhood obesity interventions carried out in the community-setting have increased (Bleich et al., 2013), there remains a paucity of studies. However, although the scarcity of studies makes it difficult to determine the impact of community-based childhood obesity prevention programmes (Waters et al., 2011, Ling et al., 2017), multi-component interventions (combining physical activity and dietary strategies), carried out in the community with a school or home component are found to be more effective in preventing childhood overweight/obesity (Ling et al., 2016).

Recent community-based multi-component lifestyle interventions (Skouteris et al., 2016, Lanigan et al., 2013), provide some insight on the efficacy of more complex interventions that actively involve parents. For example, in the MEND

(Mind, Exercise, Nutrition Do it) multi-component 10-week health lifestyle programme for families with young children (between the age of 2 and 4 years) of any weight. Skouteris et al. (2016) evaluated an intervention that targets parents/carers to promote healthy habits and make healthy behaviour changes for themselves and the whole family. Across 11 sites in metropolitan and regional areas of Australia, 201 parent-child dyads were randomised to receive the intervention (n=104), which included 90 minutes workshops relating to nutrition education, physical activity and behaviours, including active play and healthy snack time, or control (no intervention) (n=97). The RCT found positive effects on vegetable intake (p=0.01), snack food (p=0.03) and satiety responsiveness (p=0.047) at 10 weeks, and at 12 months post intervention. However, the intervention did not influence sedentary behaviour, physical activity or BMI z-score (Skouteris et al. 2016).

Likewise, in the UK, the Trim Tots healthy lifestyle programme, included nutrition education, physical activity and behaviour change, with emphasis on family involvement through art and play. The RCT recruited children (between the age of 1 and 5 years) irrespective of their weight (n=85, mean age 2.1 years), the intervention group received 10 programmes during 2 hour weekly sessions. Although, at 6 month follow up the BMI z-score was lower in the intervention group compared to the controls, the difference did not reach statistical significance (mean difference: -0.3 (95% CI -0.6, 0.3); p=0.3). However, the intervention increased active behaviour compared with controls (mean difference in active behaviour score: 3.5 points (95% CI 2.4,4.7); p<0.001) (Lanigan et al. 2013). Thus, although these lifestyle interventions have not been able to prevent weight gain, or reduce weight, they have shown that multi-component strategies involving parents are effective in changing obesity-related behaviours, which is also important in preventing the development of preschool obesity.

4.2.2.1 Social marketing campaigns in the context of preschool obesity prevention

More recently, social marketing approaches are being used in community-based obesity prevention programmes in order to improve health at the individual and population level. Social marketing[19] is now recognised as a novel concept that can be applied to tackle societal problems, including smoking cessation, drink driving, use of oral contraception, safe driving and oral health (Stead et al., 2007). Interventions that use social marketing strategies focus on promoting a healthier lifestyle for the whole population (French et al., 2000; Doak et al., 2006). For instance, social marketing strategies are increasingly used in public health policies. In the UK, the White Paper on public health has accepted social marketing as a 'marketing tool applied to social good', 'used to build public awareness and change behaviour' (Department Of Health, 2004).

Several social marketing campaigns have been designed and used in developed countries. These include Change4Life (Croker et al., 2012), and SnackRight (Richards et al., 2009) in the UK; VERB (Huhman et al., 2010) 'Let's Go! 5,2,1,0' (Rogers et al., 2013) and '5,4,3,2,1 GO!' (Evans et al., 2015) in the US; and EPODE (Ensemble Prevenons l'Obesite Des Enfants) in France (Borys et al., 2012). These campaigns primarily use social marketing strategies to provide evidence-based information in order to modify lifestyle factors and help prevent childhood overweight/obesity (Kubacki et al., 2015). For instance, a review by French et al. (2000) found that social marketing programmes could improve diet quality by increasing fruit and vegetable intake (Lowe et al., 2004), reducing energy intake (Nader et al., 1999), encouraging physical activity (Neiger et al., 2008) and providing valuable nutrition education (French et al., 2000). Although a full review and discussion of social marketing interventions is beyond the scope of this current thesis, some of these strategies have used evidence-based educational written materials to change parents' and/or children's knowledge and behaviours, and hence are reviewed here.

Most social marketing strategies have targeted parents through community centres, schools and the media, to change the home environment and encourage a healthy lifestyle for themselves and their children. One of the most extensively

[19] Defined as 'design, implementation, and control of programs calculated to influence the acceptability of social ideas, and involving considerations of product, planning, pricing, communication, distribution and marketing research' (Kolter and Zaltman, 1971).

reported campaigns is the US CDC ‘VERB It’s what you do’ campaign, which was found to increase physical activity of 9-13 year old children (Huhman et al., 2010). Two other US campaigns targeted parents and children through the use of mnemonic messages. ‘Let’s Go! 5,2,1,0’ (Rogers et al., 2013) and ‘5-4-3-2-1 GO!’ (Evans et al., 2011; Evans et al., 2015), in order to encourage a healthy lifestyle.

Let’s Go! 5,2,1,0 was evaluated in Portland, Maine in a community-based, multi-setting childhood obesity prevention programme. Families and children were reminded to make healthier choices with the help of four recommendations: eat five or more servings of fruits and vegetables; limit recreational screen time to two hours or less per day; engage in one hour or more of daily physical activity, limit sugary drinks; and drink more water and low fat milk (Rogers and Motyka, 2009). The success of the campaign was evaluated through telephone surveys conducted with 800 parents (between 2007 and 2011). Using telephone interviews over five years 2007 to 2011 with parents, Rogers et al. (2013) found that the consistent messages delivered through multiple settings (schools, child care programmes, after school programmes, health care practices, worksites and community sites) increased parental awareness from 10% to 47% ($p<0.001$), and positively influenced fruit and vegetable consumption, which increased from 18% to 26% ($p<0.001$) (Rogers et al., 2013).

The Consortium for Lowering Obesity in Chicago Children (CLOCC) that developed the ‘5-4-3-2-1 GO!’ campaign, also targeted parents as ‘agents of change’ across multiple levels of the community to deliver health promotion mnemonic messages, based on healthful eating and physical activity for children. These include consuming five servings of fruits and vegetables, four servings of water, three servings of low-fat dairy, limiting screen time to two hours or less, and engaging in one hour or more physical activity daily (Evans et al., 2007). Although this campaign has not been formally evaluated in children, Evans et al. (2011) found that parents of 3- to 7-year-old children randomly assigned to receive the 5-4-3-2-1 GO! leaflet and counselling reported an increase in the consumption of fruits and vegetables (OR= 1.75; 95%CI: 1.01 to 3.06)(Evans et al., 2011), suggesting that the 5-4-3-2-1 GO! campaign is a promising intervention that may reduce obesity-related behaviours in both parents and their children. However, further investigation in an RCT is needed to accurately evaluate its effectiveness as an obesity prevention tool.

In the UK, two social marketing campaigns: SnackRight (Richards et al., 2009) and Change4Life (Croker et al., 2012), have been evaluated. Although nutrition related advice provided by the SnackRight campaign (see, Table 4-5) demonstrated that parents spent more on fruits (not vegetables), the consumption of fruit, vegetables and healthy snacks did not change (Richards et a., 2009). An evaluation of the UK Change4life (C4L) campaign in a cluster RCT found that while the 'family information pack' from C4L significantly increased awareness of the C4L campaign and the Start4Life[20] campaign (which started a year later) in the intervention group compared to controls (see, Table 4-4), engagement in the intervention, and the impact of the intervention on attitudes and behaviours was low. This could be due to limitations in the study design, for example study outcomes did not consider all possible benefits of the campaign, or parents were unsure if they themselves or their children were targets of the campaign. It is also possible that parents did not feel the need to change, so did not actively engage in the intervention. For instance, qualitative analyses revealed that across all socio-economic backgrounds, families perceived their existing dietary and physical activity habits to be satisfactory. However, parents from lower and higher socio-economic levels reacted differently (e.g. parents in higher socio-economic level rated 'the importance of physical activity' lower than controls), and parents from lower socioeconomic levels implied that cost, unrealistic changes and time to engage with monitoring acted as barriers. Thus, findings from this study suggest that future social marketing campaigns that aim to prevent childhood obesity should be tailored to target specific populations (e.g.

[20] Following the launch of C4L in January 2009 to tackle obesity, the UK Department of Health have introduced the Start4Life campaign designed for younger children, and focuses on providing concise information on starting life with good eating and physical activity habits to help prevent childhood overweight and obesity. Start4Life also supports the Healthy Child Programme (early intervention and preventative programme) that support pregnant women, and aims to improve breastfeeding practices in England.

simplify information to increase engagement in low resource populations) (Croker et al., 2012).

4.2.3 Home-based interventions

The family home environment plays an important role in determining a child's risk of developing overweight and obesity (Lobstein, 2004). Parents, in particular, play a vital role in the development of healthy eating practices and physical activity habits. Most often, the mother decides what, when and how much food is offered to a child at meal times and controls their physical activity (Robinson et al., 2007). However, if the parents' beliefs and knowledge regarding their child's nutrition and physical activity are incorrect, and/or the parents are unable to ensure their child is meeting the requirements for a balanced diet, interventions are needed to provide the necessary information and support parents (Mitchell et al., 2013).

Parental influences on childhood obesity may include feeding styles (e.g. pressure to eat, restriction, monitoring), food availability (e.g. limiting availability of energy-dense food in the home environment), role modelling (e.g. parents should consume a healthy diet to encourage their children), and using instrumental behaviours (e.g. the use of non-food related rewards) (Skouteris et al., 2011) (see section 3.3.3.1). Interventions that target these factors can have beneficial effects on both dietary intake of the child, and weight status.

To date, a small number of studies have been conducted in the home-setting. These mainly focus on targeting the parent, and influence parental skill development in relation to feeding styles, nutrition education, and motivational interviewing. However, the efficacy of these home-based interventions remains unclear (Harvey-Berino and Rourke, 2003; Haines et al., 2013).

The Healthy Habits, Healthy Homes trial randomised 121 parent-child dyads (2- to 5-year-old children) to either receive an intervention or to a control group. The intervention included four home visits and used motivational interviewing to encourage behaviour change. Monthly coaching calls were used to assess progress and text messages were sent twice weekly for 16 weeks, followed by once weekly for 8 weeks, to provide information and behaviour change strategies. The control group received four-monthly mailed educational materials. The intervention was found to reduce BMI z-score (-0.40; 95% CI: -0.79 to 0.00; p= 0.05) compared to controls, six months after the end of the intervention (Haines et al., 2013).

Another intervention including 40 mother-child dyads randomised parents to receive support skills for obesity prevention. Home visits (one hour per week) focused on adopting appropriate eating and physical behaviour and exercise. The control group received general parental support skills for one hour per week (Harvey-Berino and Rourke, 2003). Although there were no statistical differences in weight status and energy intake between intervention and control at the end of the intervention (16 weeks), the intervention reduced maternal restrictions on child feeding ($p<0.05$).

To better summarise the current evidence of different intervention approaches used to prevent preschool overweight and obesity, systematic reviews and meta-analyses are further reviewed below in Section 4.3.

4.3 Review of findings from systematic reviews and meta-analyses focusing on the prevention of preschool obesity

To date, ten systematic reviews have summarised findings from interventions focused on preventing preschool obesity (Bluford et al., 2007; Campbell and Hesketh, 2007; Saunders, 2007; Hesketh and Campbell, 2010; Bond et al., 2011; Monasta et al., 2011; Waters et al., 2011; Nixon et al., 2012; Ling et al., 2016)(see, Table 4-1). Findings from some systematic reviews and meta-analyses presented in Table 4-1 are discussed below.

Hesketh & Campbell (2010) identified 23 intervention studies carried out between 1995 and 2008, of which nine were conducted in the preschool/childcare setting, eight were home-based, and the remaining were either a group setting, primary care setting or group setting. Fourteen were single component interventions, of which eight focused on modifying dietary behaviour, five focused on increasing physical activity, and one reduced sedentary behaviour. The remainder were multicomponent interventions, five combined physical activity and dietary behaviours, two combined physical activity and sedentary behaviour, and two combined dietary and sedentary behaviour. However, while some intervention studies included in the review showed some degree of effectiveness on behaviours related to obesity (Dennison et al., 2002; Williams et al., 2002; Harvey-Berino and Rourke, 2003; Wardle et al., 2003; Trost et al., 2008), others showed no effect, or the impact of the intervention in reducing BMI was unclear (Hesketh and Campbell, 2010). Overall, the review suggests that although interventions did not effectively prevent obesity, evidence of positive effects observed in interventions targeting obesity-related behaviours in different settings provide useful insights into the most effective strategies.

Monasta et al. (2011) summarised the effectiveness of seven RCTs for the prevention of overweight and obesity among children younger than 5 years (between 1997 and 2008). The review found no evidence of an effect from either single or multiple-component interventions on the prevention of excess weight gain in preschool children (Monasta et al., 2011). Both systematic reviews found that the involvement of parents promoted the adoption of positive dietary, physical activity and sedentary behaviours (Hesketh and Campbell, 2010; Monasta et al., 2011).

Another systematic review focused on identifying effective behavioural models and strategies to prevent preschool obesity (published between 1995 and 2010). The review included children aged between 4 and 6 years (Nixon et al., 2012). Of the 12 studies included, all interventions used behaviour change strategies to target dietary intake, physical activity or sedentary behaviour, or a combination of two behaviours, and nine additionally used theoretical underpinnings (e.g. social cognitive theory). Four of the 12 studies reported a favourable effect on BMI, and seven reported benefits for physical activity and/or dietary behaviour.

Similar to earlier reviews, Nixon et al. (2012) concluded that the most effective interventions involved parents, targeted dietary intake and physical activity, and included at least one behaviour change strategy (e.g. educating parents and children about the benefits of healthy eating using parental modelling and physical activity). Additionally, the authors highlighted the importance of using appropriate theoretical underpinning of behavioural change when developing preschool obesity prevention interventions, which has been recommended previously (Sharma, 2007; Summerbell et al., 2012). Theoretical frameworks include the health belief model, the theory of planned behaviour, social cognitive theory, the trans-theoretical model and the socioecological model. A detailed description of these can be found in **Appendix F**.

To date, only two systematic reviews carried out meta-analyses of obesity prevention studies in preschool children (Waters et al., 2011; Ling et al., 2017). Only one Cochrane review of childhood overweight and obesity prevention studies that included preschool children has been carried out. The review identified 55 childhood obesity interventions, of which nine targeted preschool children (aged 0-5 years) (Waters et al., 2011). Five of these were randomised controlled trials, four of which were conducted in the preschool/child-care setting (Mo-suwan et al., 1998; Dennison et al., 2004; Fitzgibbon et al., 2005; Reilly et al., 2006), and one was home-based (Harvey-Berino and Rourke, 2003). Two interventions focused solely on increasing physical activity (Mo-suwan et al., 1998; Reilly et al., 2006) were not successful in reducing BMI. Of the three trials that included both dietary and physical activity components (Harvey-Berino and Rourke, 2003; Dennison et al., 2004), only one was successful in reducing BMI (Fitzgibbon et al., 2005).

Waters et al. (2011) review and meta-analyses found that interventions were more effective in reducing BMI z-score in the younger age groups (0-5 years); -0.26kg/m^2 (95% CI:-0. 53 to 0.00) compared to older age groups; -0.15kg/m^2 (95% CI -0.23 to -0.08) (6-12 years), and -0.09kg/m^2 (95% CI -0.20 to 0.03) (13-18 years) (Waters et al., 2011). Hence, the findings from Waters et al. (2011) highlight the importance of early prevention during the preschool years, in order to instil long-term healthy dietary patterns and physical activity behaviours to reduce the risk of developing overweight and obesity (Waters et al., 2011).

Ling et al. (2016) reviewed 23 interventions to prevent preschool obesity. Most included studies were from the US and the remainder were from other developed countries (e.g. European countries and Australia) and developing countries (e.g. Thailand). Studies varied widely in relation to design, sample size, intervention component, setting, mode of delivery, outcome measures, duration and follow up. All but two were multicomponent interventions (Annesi et al., 2013a; Annesi et al., 2013b) and involved parents at varying levels.

Overall, Ling et al., (2016) found that most interventions took place in the preschool setting, followed by community/clinics, and one was home-based. Theoretical models were used in most of the effective interventions (Fitzgibbon et al., 2005; Berry et al., 2011; Barkin et al., 2012; Slusser et al., 2012; Zask et al., 2012; Annesi et al., 2013a; Annesi et al., 2013b). This is consistent with Glanz et al. (2008) suggestion that basing interventions on behavioural theory or models is likely to enhance programme outcomes. However, those studies that did not report a theoretical underpinning were also successful in reducing BMI or changing behaviour (Eliakim et al., 2007; Haines et al., 2013; Nemet et al., 2013). This could be explained by intervention programmes focusing behaviour change strategies (e.g. developing skills, self-efficacy, educating parents on the benefits of healthful dietary and physical activity changes), and the active involvement of parents (Glanz et al., 2008). Therefore, researchers suggest that rather than the use of interventions explicitly underpinned by a theory or behavioural models, targeting specific behaviours (e.g. both diet and physical activity behaviours), and involving parents are key factors to the success of obesity prevention interventions in children.

More recently, Ling et al., (2017) updated their systematic review and carried out a meta-analysis of 30 obesity prevention interventions in preschool children. The pooled effect size was -0.19 (95% CI: –0.28, –0.09) kg/m^2, with sustained effects (effects from post-intervention to follow-up) of -0.21 (95% CI:-0.35, -0.08) kg/m^2. The meta-analysis also highlighted some important findings in relation to intervention approaches. Ling et al., (2017) indicated that although school-based interventions are the most popular setting for prevention interventions, home and community based interventions were found to have larger effects compared to those implemented in the school setting. More interestingly, the review showed that face-to-face delivery of parental interventions did not produce greater effects compared to other methods of intervention delivery (e.g. phone, auditory transmission, website and mailing of materials). These findings therefore highlight the promise of interventions delivering written materials (e.g. leaflets), and the future of E-health-promoting interventions delivered via internet and mobile channels (Ling et al., 2017).

4.3.1 Conclusions drawn from findings of systematic reviews and meta-analyses

There is a growing body of evidence on the effectiveness of preschool obesity prevention interventions, however, findings from systematic reviews remain inconsistent and inconclusive. The generalisability of findings from preschool obesity prevention interventions is also problematic due to the heterogeneity of interventions, which includes: (i) differences in the study design (e.g. randomised controlled trials or non-randomised controlled trials); (ii) varying sample sizes; (iii) the nature of intervention setting (e.g. home or school setting); (iv) the use of theoretical underpinning for behaviour change (e.g. social cognitive theory); (v) the intervention strategies employed (e.g. physical activity, dietary or a combination of both); (vi) the duration and follow-up period (e.g. 6 weeks, 12 weeks); and (vii) the different definitions of obesity and outcomes measured, make comparisons difficult (Bond et al., 2011; Ling et al., 2016; Bluford et al., 2007; Hesketh and Campbell, 2010; Monasta et al., 2011; Waters et al., 2011; Ling et al., 2017).

Additionally, the varying levels of success reported by different intervention studies (Waters et al., 2011; Ling et al., 2017) make findings from systematic reviews hard to compare. While some systematic reviews report that there is currently insufficient evidence to suggest which intervention approach is most effective in preventing preschool obesity (Bluford et al., 2007; Saunders, 2007; Monasta et al., 2011; Waters et al., 2011), others have identified interventions with beneficial effects (Campbell and Hesketh, 2007; Hesketh and Campbell, 2010). For instance, some prevention interventions that did not report significant changes in relation to BMI were able to demonstrate significant behaviour changes conducive to better heath (Wilfley et al., 2007; Kubicky, 2012). These include reducing screen time/sedentary behaviour (Dennison et al., 2004), reducing restrictive feeding (Harvey-Berino and Rourke, 2003), increasing physical activity or reducing energy intake (Fitzgibbon et al., 2006).

Additionally, most previous interventions for preschool obesity are of high intensity (i.e. highly dependent on frequent interactions between interventionists, children and/or parents), and focus on the repetition of targeted messages through group or single sessions. Although some of these high intensity interventions have resulted in small but potentially meaningful behaviour changes (Fitzgibbon et al., 2005; Skouteris et al., 2016), not all have considered cost-effectiveness (Campbell and Hesketh, 2007; Ling et al., 2017). Given the high intensity nature of these studies, it would be expected that the high cost limits feasibility and global application in low or middle-income populations (Hesketh and Campbell, 2010). Therefore, there is currently insufficient evidence to identify which intervention strategies are most effective in preventing preschool obesity. Hence, more research is needed to determine the strategies, and study design (setting, duration etc.) that are most cost-effective and generalisable to a wider population (Bluford et al., 2007).

Moreover, most current evidence for interventions is from developed countries. Therefore, the feasibility of these complex interventions in different countries may vary considerably with respect to wealth, culture and ethnicity (Campbell and Hesketh, 2007). Middle and low-income populations in poor resource settings face challenges in finding the time, resources and health infrastructure required, and need support to develop intensive interventions. Also, since the long-term effectiveness of intensive obesity prevention interventions remains unclear (Bluford et al., 2007; Hesketh and Campbell, 2010; Waters et al., 2011), research is needed to investigate whether low-level intensity or minimal interventions would result in similar findings (Jeffery and Gerber, 1982; Glasgow et al., 2014).

Overall, taking into consideration the different approaches available to prevent preschool obesity, and the current evidence base available, most researchers agree that multi-component interventions, including both physical activity and dietary intervention components in a variety of settings with parental involvement, are likely to be most effective (Kitzmann and Beech, 2006; Campbell and Hesketh, 2007; Birch and Ventura, 2009; Waters et al., 2011; Nixon et al., 2012; Ling et al., 2016).

Interventions targeting parents to promote healthy eating practices and physical activity can be divided into two categories: (i) 'intensive': i.e. require parent involvement (with or without the child) in programmes sessions, workshops etc.; (ii) 'simple/minimal' educational programmes (leaflets, newsletters, and/ or booklets), which have been used as stand-alone interventions or adjacent to educational programmes to provide parents with relevant information about healthy diets and physical activity. The former type of interventions targeting parents has been discussed in section 4.2. Therefore, with relevance to the current research, the effectiveness of multi-component interventions involving parents solely as 'agents of change' using minimal interventions (i.e. simple 'educational' materials and reinforcement) to prevent preschool obesity are discussed below.

Table 4-1 Summary of evidence from systematic reviews of preschool obesity prevention interventions

Review	No. of Included studies	Summary of findings
Saunders, 2007	6	Lack comprehensive evidence of effective strategies to prevent obesity in children under the age of 5
Bluford et al., 2007	5	Scarcity of findings limits generalizability and highlights the need for evaluated preschool obesity prevention programmes in different settings and racial/ethnic groups
Campbell and Hesketh, 2007	9	All included studies showed some level of effectiveness on at least one obesity-behaviour, but not obesity
Hesketh and Campbell, 2010	23	Suggest that interventions should target behaviours that contribute to obesity to promote healthy weight from early childhood.
Bond et al., 2011	4	Suggest future interventions should include cultural sensitivity, moderate to vigorous exercise, parental engagement and both dietary and physical activity components.
Monasta et al., 2011	17	No trial had an effect on preventing preschool overweight and obesity
Waters et al., 2011	9	Inconclusive evidence for interventions preventing preschool obesity. Meta-analyses found interventions in younger children (0 – 5 years) were more effective in reducing weight (BMI z-score) -0.26kg/m^2 (95% CI:-0. 53, 0.00) compared to older age groups.
Nixon et al., 2012	12	Interventions that included parental involvement, interactive learning, physical activity and dietary interventions and long-term follow-up were most effective.
Ling et al., 2016	23	Challenging to draw definitive conclusions due to the heterogeneity of the included interventions. Suggest that targeting both child and parent through physical activity and nutrition may be more effective in preschool obesity prevention.
Ling et al., 2017	30	Meta-analyses of prevention intervention studies found the pooled effect size was -0.19kg/m^2 (95% CI:-0. 26, -0.09), with sustained effects (-0.21kg/m^2 (95% CI:-0. 35, -0.08).

4.4 Minimal interventions: an introduction

In comparison to 'high intensity' interventions that involve regular sessions, workshops and/or activities, 'low-intensity' intervention or minimal interventions that focus on delivering relatively simple and easily disseminated information have been attempted. These typically involve a simplified series of verbal instructions and in some cases also provide materials (e.g. leaflets) with specific behaviour change instructions for self-implementation.

A major benefit is that these require little assistance or contact with interventionists, and so are less costly. Minimal interventions can be delivered through print (leaflets, booklets, and newsletters), in the form of video or audiotape, or through computer programs (e.g. mobile apps) (Black and Cameron, 1997; Glasgow et al., 2014). Minimal interventions are mainly based on 'self-change/self-cure' techniques. They are usually delivered in a structured and organised method by a researcher to provide instructions, and verify progress via regular telephone calls.

At present, the use of leaflets in health care is widespread, partly because of public demand, but also due to financial and time-constraints in primary care (Hunter, 2005). However, although minimal interventions have a vital place in health promotion (e.g. smoking cessation (Dawley and Finkel, 1981; Fisher Jr and Rost, 1986; Price et al., 1991), exercise (Brownell et al., 1980; King et al., 1988) and disease prevention (e.g. applied in a variety of health-related fields, including and weight loss programmes), the ability of these to increase knowledge or bring about behaviour change is currently unknown (Murphy and Smith, 1993; Mitchell et al., 2013). Most minimal interventions have been considered a viable alternative to usual care, when used independently, or as part of a comprehensive intervention mix. However, the use of leaflets or minimal interventions is currently limited to a small number of adult studies using leaflets to bring about weight loss, and those promoting a healthy lifestyle in children.

4.4.1 ‘Minimal’ Leaflet-based interventions used in adults

Although the current PhD thesis focuses on preschool children, drawing from evidence of minimal/leaflet-based interventions carried out in adults provides greater insight on the acceptability, feasibility and prospect of using simple educational interventions in preventing obesity in children.

Black (1987) was one of the first to demonstrate that weight loss could be achieved and maintained following minimal intervention. Benefits of self-administered minimal interventions that can yield comparable results to comprehensive interventions, yet are simple and less costly have since been reported by others (Hultsman et al., 1987; Black and Hultsman, 1988; Scogin et al., 1990; Black et al., 1991)(see, Table 4-2). It has even been suggested that minimal interventions may be more effective compared to complex ones. For instance, a meta-analysis of self-administered interventions by Scogin et al. (1990) concluded that self-instructed interventions are comparable to face-to-face programmes for weight loss (Hagen, 1974; Jeffery and Gerber, 1982; Dennison et al., 1996).

Interventions using leaflets in adult weight management in clinical and community settings have shown some success (Black et al., 1984; Beeken et al., 2017). Black and colleagues evaluated the use of minimal interventions (using a leaflet) and report some success (Black and Threlfall, 1986). For example, Black et al. (1984) found that overweight individuals receiving a minimal intervention based on three verbal instructions ((i) eat a nutritious, well-balanced diet from the four basic food groups, (ii) find ways to increase physical activity without necessarily engaging in strenuous exercise; and (iii) lose weight slowly and gradually at a rate not to exceed two pounds a week) lost an average of 4.9 kilograms (11lbs) at the end of the 7-month intervention. However, compared to shortened behavioural weight loss programmes, differences in weight loss were not statistically different between groups (Black et al., 1984).

More recently in the UK, in a two-arm, individually randomised controlled trial, Beeken and colleagues (2017) examined the effectiveness of a minimal intervention with usual care (control) in a primary care setting. The simple intervention 'Ten Top Tips' (10TT) a habit-based weight loss advice leaflet (based on habit-formation theory[21]) focused on making simple dietary and activity behaviours habitual(Gardner et al., 2012). In a sample of 537 obese adults, those randomised to intervention 10TT were found to lose more weight over three months compared to those receiving usual care (mean difference= -0.87kg; 95%CI: -1.47, 0.27; p=0.004). However, at 24 months after completing the intervention, although, the intervention group maintained their weight loss, there was no difference in the weight lost between the intervention and usual care group (controls). The authors suggested that the similar weight loss achieved by both groups could be because the usual care group may have been referred to commercial weight loss programmes, and therefore the weight loss achieved may have been delayed compared to the immediate delivery of the 10TT. Nevertheless, the novel and simple habit-based weight loss intervention was found to be effective in the short-term compared to usual care, and considering the feasibility and low-cost (~£23/subject), such minimal self-guided leaflet may be a feasible and alternative option for those who find commercial or more intensive weight loss programmes impractical (Beeken et al., 2017).

[21] Based on the theory that habits are automatically triggered actions which are learned by repeating a behaviour in a consistent context until it no longer requires conscious effort (Gardner et al., 2012).

Table 4-2 Benefits of minimal interventions compared to intensive interventions

Cost	• Applicable to use in low resource and lower socioeconomic groups • Use professional time sparingly and efficiently compared to comprehensive interventions • Can incorporate trained volunteers to provide services at reduced or minimal costs
Efficiency	• Provides minimal amount of intervention necessary to produce a positive health outcome or behaviour change • Less intensive interventions and can be used before/with and often in place of more comprehensive (intensive) interventions
Convenience	• Minimal disruption or interference with normal day activities (e.g. work schedule) • Demand less time and offers more scheduling flexibility • Ease of dissemination, due to the simplicity, compatibility and generalizability
Transferability and Reapplication	• Ability to pass an intervention along to others, and reach a larger population • Materials provided can be shared and therefore influence others not directly reached • Reapply or repeat easily • Ability to culturally adapt simple information to suit different populations

(Hultsman et al., 1987; Black et al., 1991)

4.4.2 'Minimal' educational/leaflet based interventions targeting children

Whilst the adult studies discussed above suggest that leaflets are a feasible health promotion strategy that may be effective at least in the short-term to reduce weight, evidence for the use of leaflets to improve children's eating behaviour and/or prevent obesity is scarce in the literature (see summary in Table 4-5).

Largely, these interventions assume that by improving nutrition knowledge and awareness among parents, behaviour change will follow. For instance, several studies have shown that higher level of nutrition knowledge among mothers was associated with higher fruit and fibre intake, and lower intake of fat in children (Gibson et al., 1998; Variyam et al., 1999). Therefore, if efforts are focused on how and what parents feed their children, these knowledge-based educational interventions may show some promise. These simpler 'educational' interventions are discussed below.

Wardle et al. (2003) examined the effect of a leaflet for parents that aimed to improve food preference and increase consumption of moderately liked vegetables among 2- to 6-year-old children. The intervention randomised parents of children to either (i) a leaflet consisting of advice on how to increase a child's fruit and vegetable intake; or to (ii) an exposure group, which received instructions to expose their child to their least favourable vegetable for 14 days, and avoid the use of rewards for consumption; or to (iii) a control group that received no instruction or informative advice (Wardle et al., 2003). Children of parents randomised to the exposure group showed significant increases in liking, ranking and consumption of fruits and vegetables after 14 weeks. However, those randomised to the leaflet did not change their intake of vegetables and fruits. The lack of effect reported for the leaflet could possibly be due to children not accepting food that they were told was healthy (Wardle and Huon, 2000), and since the leaflet used emphasised health issues parents may have tried to force feed their child, which could have adversely influenced liking and preferences.

Essery et al. (2008) compared the efficacy of written information on child feeding practices and physical activity behaviours in preschool children. Parents were randomised to receive the same information in either (i) four page newsletters every week for 12 weeks or (ii) a 52-page booklet that included all the information given all at once, or (iii) no information (control). Following the intervention period (12 weeks), only the 'pressure to eat' score, which assessed how much pressure the mother used during child feeding situations decreased in the newsletter group, compared to the controls (mean pressure to eat score decreased from 2.5 to 2.1; $p<0.01$). No differences were observed in child feeding factors (restriction, monitoring, perceived responsibility) or physical activity practices (active play or television viewing time). These findings suggest that it may be more useful to provide information through simplified four page newsletters compared to more dense versions (e.g. a 52-page booklet). However, the lack of conclusive findings from this study highlights the need for more studies to evaluate whether dense information is as effective as simple information, provided regularly (Essery et al., 2008).

More recently, the Mealtime Magic programme investigated the use of leaflets given to 223 parents of children under the age of 5 over a six week period in five UK primary care practices to encourage healthy feeding (Inglis et al., 2010). Each parent was given a leaflet, and verbal reinforcement of three messages: (i) foods should be presented up to 20 times to encourage familiarity and increase the chance of children choosing those foods themselves; (ii) a wide variety of foods should be offered, rather than sticking to their child's favourite foods, to encourage a healthy diet; (iii) parents should avoid telling children to eat everything placed on their plate if it makes them eat more than they actually want. Of the 110 who completed follow-up measures, most of the parents (92%) reported that the information and advice provided was valuable and useful (100/109), 52% found that the advice increased their confidence in what they may have already known (57/110), and 47% reported positive behaviour changes (49/105). However, this intervention was not evaluated in a RCT design. Therefore, the relative effectiveness of the leaflet alone compared to the leaflet in conjunction with verbal reinforcement is unclear (Inglis et al., 2010).

Another parent-focused intervention 'Healthy Feeding Habits' evaluated an intervention promoting habit formation of three healthy feeding behaviours (serving fruit and or vegetables, serving healthy snacks, and serving non-sweetened drinks) in a cluster RCT (McGowan et al., 2013). A total of 126 parents of preschool children (2 to 6 years) were recruited from six child care centres in the UK, and were cluster-randomised to receive training on habit formation of three feeding behaviours, or control. At the 8 weeks follow-up the intervention was found to significantly increase parental habit strength for feeding behaviours, and increase children's intake of vegetables ($p=0.003$), healthy snacks ($p=0.009$) and water ($p=0.032$) compared to controls. These results therefore suggest that an intervention built on habit-formation (i.e. repeating a behaviour so that it becomes an automatic response) could possibly prove to be a useful behaviour change strategy in preschool obesity interventions, particularly those focused on energy-balance related behaviours(McGowan et al., 2013; Gardner et al., 2014).

In summary, leaflets delivering simple evidence-based information to promote a healthy lifestyle by targeting parents to prevent childhood overweight/obesity are limited in the literature. In addition to those previously used in social marketing campaigns, that provide mnemonic nutrition and exercise advice (Rogers et al., 2013, Evans et al., 2015) (see section 4.2.2.1). The Ten Steps for Healthy toddlers developed in the UK also provides simple and sound nutrition advice for parents to promote a healthy lifestyle in aims of preventing the development of childhood overweight and obesity.

4.4.2.1 Ten Steps for Healthy Toddlers

The Ten Steps for Healthy Toddlers leaflet, produced by the Infant and Toddler Forum, is a consensus document from an expert group of health care professionals (paediatricians, dietitians, health visitors and psychologists). The leaflet was based on current UK government advice, and drew on existing evidence for toddler nutrition, and expert opinion. The Ten Steps for Healthy Toddlers provides consistent, simple and sound nutritional advice that can be applied wherever toddlers are fed, in order to achieve good habits for health, growth and development. The leaflet provides parents/carers ten easy to follow steps highlighting positive strategies to cater for a toddler's nutritional needs, and ensure positive attitudes towards food and physical activity. A detailed description of these steps and the evidence behind them is summarised in **Appendix G**.

Although the Ten Steps for Healthy Toddlers leaflet has not been previously used as an intervention tool, the Preschool Learning Alliance the UK has incorporated the ten steps in 117 registered childcare settings, and the acceptability and effectiveness of the ten steps was evaluated (**Appendix H**). Following the adoption of the ten steps by managers of 27 childcare settings, responses were measured after six months. These focused on: (i) behavioural changes in staff; (ii) improved confidence of staff in dealing with meals and snack times; (iii) positive engagement of parents. Table 4-3 presents a few of the improvements in behaviours[22] (**Appendix H**). Overall, the Ten Steps for Healthy Toddlers was well accepted, and the steps rated most useful by the 27 settings were *Step 2* 'you decide which nutritious foods to offer, taking account of individual dietary needs, but let children decide how much to eat', *Step 7* 'respect children's tastes and preferences, don't force feed, and *Step 4* 'have a routine, offering three meals and two-three snacks over the whole day'.

Table 4-3 Behavioural improvements observed following the adoption of Ten Steps for Healthy Toddlers

Response of managers from 27 childcare settings following 6-month adoption
Behavioural changes in staff
78% (21/27) staff and children interact well at meal/snack times
78% (21/27) respect each child's decision when they say they have eaten enough
74% (20/27) have adopted a regular routine of snacks and mealtimes
63% (17/27) only offer milk or water as drink with meals
67% (18/27) of children are active for at least 2.5 hours during a full day at setting/nursery
67% (18/27) do not use food and drink as a reward
Improved confidence of staff in dealing with meals and snack times
93% (25/27) of staff found the ten step posters helpful
63% (17/27) of staff are more confident in dealing with feeding issues
59% (16/27) of children are more involved in meal times as learning experiences
Positive engagement from parents
74% (20/27) received feedback from parents – no negative feedback received
44% (12/27) reported parents engaged with staff about food and physical activity

4.4.3 Conclusion

Overall, research investigating the efficacy of leaflets promoting healthy eating practices and physical activity in children is limited (Showell et al., 2013), as such the benefits of such educational approaches in preschool obesity prevention interventions and social marketing campaigns require further evaluation in order to examine their long-term effect.

[22] Presented by Judy More (Paediatric Dietitian, Member of the Infant and Toddler forum).
Poster presentation awarded first prize at the 2013 Community Practitioner and Health Visitors Association (CPHVA) conference.

Nevertheless, in consideration of the evidence from adult studies utilising simple advice in the form a leaflet for weight loss (Black and Cameron, 1997; Beeken et al., 2017), and the promising evidence from educational interventions underscoring that parents are able to successfully influence behavioural change and promote a healthy diet in children (Wardle et al., 2003; Inglis et al., 2010; Haines et al., 2013; McGowan et al., 2013). The use of leaflets to increase nutrition knowledge and awareness may potentially be useful and may help reduce obesity where resources and access to health/nutrition education are limited. Thus, the rationale for using simple informative leaflets or tools in the UAE is discussed in the next section.

4.5 Rationale for the prevention of preschool obesity in the UAE and neighbouring Arab Gulf Countries: addressing the gap in the research

The systematic review in Chapter 1 found that the prevalence of preschool obesity in the UAE and neighbouring Arab Gulf countries is high and maybe rising. However, no previous study has investigated risk factors for preschool obesity in the UAE (see section 2.4). Identifying obesity risk factors is key in order to inform and develop suitable preventative interventions. Hence, an aim of the current research is to investigate early life risk factors (developmental, dietary, physical activity and behavioural) responsible for preschool obesity in Al Ain, in the UAE.

As presented earlier (see section 4.3), most interventions aiming to prevent childhood obesity have been carried out in developed countries (Ling et al., 2016), and little is known about the feasibility and effectiveness of childhood obesity prevention in developing countries (Waters et al., 2011). In particular, no intervention has been investigated for the prevention of preschool overweight and obesity in the UAE. Therefore, there has been much debate about the best strategies for prevention of childhood obesity in the UAE and neighbouring Arab Gulf countries, and whether existing interventions, conducted mainly in Western countries, are applicable to countries in this region (Al Dhaifallah et al., 2015).

To date, only one study in the Arabian Gulf region has investigated the effectiveness of an intervention on childhood obesity in an RCT. In Kuwait, Boodai et al. (2014) tested an intervention, for treatment rather than prevention of obesity, in adolescents aged between 10 and 14 years. The National Adolescent Treatment Trial for Obesity (NATTO) was based on evidence from the Scottish Childhood Obesity Treatment Trial (SCOTT) (Stewart et al., 2005). Although the intervention proved feasible, it had no effect on BMI z score or other proxy measures of obesity relative to control. Attendance was also low; only 29% of participants attended more than four out of the six sessions. This may have been due to the lack of concern about obesity amongst parents of adolescents in Kuwait (Boodai et al., 2014).

Other factors that may have influenced retention and engagement in the intervention include: (i) low levels of nutritional knowledge (e.g. the absence of resources, printed materials, media campaigns promoting a healthy lifestyle) (El-Sabban and Badr, 2011); (ii) poor parental perceptions regarding their child's weight status (Al-Qaoud et al., 2010; Aljunaibi et al., 2013); and (iii) resistance of parents to participate or staying engaged in obesity treatment/prevention programmes, if they believe that their child does not need treatment.

Musaiger et al. (2013) found that the most prominent obstacle/barrier to healthy eating and physical activity in the Arabian Gulf region in adolescents was the 'lack of information on healthy eating and physical activity' (Musaiger et al., 2013). Similarly, a study in the UAE (Ras Al Khaimah city) reported that most participants (students, parents and teachers) believed that 'lack of education'; 'unhealthy foods' and 'limited access to physical activity' were the main barriers to healthy eating and physical activity (Stott et al., 2013).

Other barriers or challenges were related to: (i) 'climate hindrances', for example, one student stated, 'the weather here (UAE) is really hot and it deters kids from playing outside'; (ii) 'clothing attire' was found to restrict outdoor activities especially for females, and (iii) 'cultural traditions', related to local food patterns. For example, refusing food is considered impolite, and the consumption of meals through large shared serving plates hinders an individual's ability to estimate portion sizes (Musaiger et al., 2011b).

Parental recognition of their child's weight status is essential for the success of obesity prevention strategies (Parry et al., 2008). Parents play a vital role in influencing a child's eating habits and physical activity, and parental perception about their child's weight can influence their motivation to seek information and make changes to feeding practices (Thompson, 2010). However, there is an alarming disconnect between a child's actual weight and parental perceptions of their child's weight status (Killion et al., 2006; Robinson and Sutin, 2016). Globally, among certain ethnic groups, fewer than 50% of parents are able to recognise that their child is overweight (He and Evans, 2007; Parry et al., 2008). In particular, parents are found to underestimate the degree to which their child was overweight (Vuorela et al., 2010). This could be influenced by social stigma, cultural norms or could simply be due to unawareness.

In the Arabian Gulf region, parents' perceptions of weight may be influenced by cultural norms (for example, plumpness is considered a sign of affluence and health) and so many parents may misclassify their child's weight status (Hashemi, 2009; Hussin et al., 2011; Aljunaibi et al., 2013). In the UAE, Al Junaibi et al. (2013) found that 33.8% of parents misclassified the weight status of their 6-19 year old child, and misclassification was highest among parents of overweight/obese children (63.5%). Similarly, in Saudi Arabia, 90% of parents of overweight children aged between 6 and 10 years old reported that their child was of normal weight (Al-Mohaimeed, 2016). These findings highlight that certain cultural perceptions exacerbate misclassification and, if parents are unable to recognise their child's risk of developing obesity, they may disregard the need for intervention.

Health promotion interventions need to take into consideration the socio-cultural barriers and religious beliefs within the local setting, in order to be acceptable, engage participants and produce desired outcomes (Qureshi, 1996). Many researchers in the Arabian region therefore advocate the development of health promotion campaigns within the framework of Islamic rulings, cultural factors and social norms (Al Dhaifallah et al., 2015). As such, it is widely accepted that the exclusion of sociocultural values prevents acceptance of health promotion strategies (Barkin et al., 2012; Burton et al., 2017). For instance, as previously discussed (see section 2.4.3.2.3), the influence of religious beliefs (as in the Holy Quran) on breastfeeding have previously been used as a strategy to promote breastfeeding for a duration of two years in the UAE (Littlewood and Yousuf, 2000; Radwan, 2013).

4.5.1 Drawing upon the evidence: justification of intervention chosen

Taking into account the literature discussed earlier, overall researchers agree that core elements of preschool obesity prevention interventions should be multi-component and include nutrition education, promotion of healthy eating habits, physical activity, and behaviour modification to encourage a healthy lifestyle and reduce the risk of developing obesity. Additionally, the inclusion of parents is considered essential (Bautista-Castaño et al., 2004; Rudolf, 2017).

In relation to the UAE, given that there is currently a lack of public health awareness, nutrition education and health promotion campaigns (Musaiger et al., 2011a; Abdul-Rasoul, 2012), and the fact that no previous preschool obesity prevention intervention has been investigated in the UAE. It is reasonable to suggest that an intervention that focuses on increasing nutrition knowledge by providing simple and easily digestible advice for parents regarding their child's diet and physical activity habits may be useful. Earlier educational interventions aiming to increase parental knowledge have provided valuable insight. For instance, one programme that used a leaflet and verbal reinforcement of three messages to encourage healthy feeding (Mealtime Magic in the UK, see Table 4-5) reported that 92% of parents (of children under the age of 5) found the information 'useful' and 'valuable' (Inglis et al., 2010). Similarly, social marketing campaigns using mnemonic leaflets to promote healthy eating and exercise for children, were both well accepted and increased parental nutrition knowledge and awareness (see, Table 4-4) (Rogers et al., 2013; Evans et al., 2015).

To date a few educational leaflets have been developed to encourage a healthy lifestyle and prevent preschool obesity. However, considering modifiable obesity-promoting behaviours discussed in Chapter 2, and the importance of parents in influencing a child's behaviour (see section 3.3.3.1). It is sensible to use the Ten Steps for Healthy toddlers as a tool that can be culturally modified to provide helpful, concise and evidence-based advice to promote a healthy lifestyle in preschool children in the UAE (see section 4.4.2.1).

Evaluation of such an intervention would provide insight into the needs of the population it is being tested in. Hence, a key aim of the current study is to investigate the efficacy of a simple healthy lifestyle leaflet for toddlers[23] to prevent overweight and obesity among Emirati preschool children. The tool will be adapted taking into consideration the points above. For a full description of the adapted version of the Ten Steps for Healthy Toddlers Leaflet, see section 6.9.2.

[23] Adopted from the Infant and Toddler forum in the UK (details of the tool are described in Chapter 6).

Table 4-4 Social marketing campaigns designed to improve diet and physical activity of children

Author	Study design and characteristics	Intervention component	Findings
Croker et al., 2012	Evaluate the impact of a 'family information pack' element of *Change4Life (C4L)* national obesity prevention campaign in England 3774 families of 5-11-year-old children Cluster RCT of 40 primary schools	**Intervention:** mailed C4L 'Family information pack' designed to i) increase awareness of the health risk of excess body fat, ii) reduce calorie intake and develop healthier eating habits (reductions in foods high in added sugar and fat, a more regular meal pattern, less snacking, and increased fruit and vegetable intake), and iii) participate in regular physical activity (especially family activities) and reduce sedentary time. **Control:** received usual care (included standard healthy lifestyle messages e.g. five-a-day)	Awareness of campaign increased significantly in the intervention group (96% v 87%) Engagement was low 34% (n=1419) families completed follow-up data after six months.
Evans et al., 2011	*5,4,3,2,1 Go!* Social marketing campaign aims to address obesity by targeting parents at multiple levels including public service announcements, school programmes, and presentations in community settings Parents of 3 to 7-year-old	Five recommendations include: eat **five** servings of fruit and vegetables, consume **four** servings of water, eat **three** servings of low-fat dairy, limit screen time to **two** hours or less, and engage in **one** hour or more physical activity daily	Parents who received the programme counselling and materials were more likely to exhibit positive changes in fruits and vegetable intake (OR 1.75; 95% CI: 1.01 to 3.06) than those who did not.
Rogers et al., 2013	*Let's Go 5-2-1-0* Multi-setting community-based childhood obesity prevention program on participants in 12 communities in Maine	Four recommendations for healthy eating and physical activity include; eat **five** or more servings of fruits and vegetables, limit of **two** hours or less of recreational screen time, engage in **one** hour or more of physical activity, and '**limit** sugary drinks; drink more water and low fat milk.	Fruit and vegetable consumption increased (18% to 26%; $p < .001$); limiting sugary drinks increased (63% to 69%; $p=0.011$).
Richards et al., 2009	*SnackRight* Cross-sectional study at two time points before and three months after a social marketing intervention designed to improve snacking habits of preschool children in less affluent areas in the UK.	Key messages in advice leaflet included: importance of replacing unhealthy snacks with healthy snacks; information about preparing healthy snacks;information about the cost of healthy snacks; benefits to the child of healthy snacking; price benefits of fresh fruit and vegetables; parent should administer 'tough love' in encouraging their children to eat well;healthy snacks can be quick and easy to prepare; choices made when the child is young have a long-term impact; benefits to child's behaviour; negative effects of unhealthy snacks.	Increased spending on fruit (but not vegetables) (x^2 = 15.9; $p=0.007$) and more positive attitudes towards fruits and vegetables

Table 4-5 Parent-focused information based interventions to improve diet, physical activity and prevent preschool overweight and obesity

Author	Study characteristics	Intervention components	Findings
Haines et al., 2013	*Healthy Habits Healthy Homes* 121 parent-child dyads 2-5-year-old children Home based RCT Duration: 6 months	**Intervention**: physical activity and diet focused, included four home visits: motivational interviewing, monthly coaching calls, text messages twice a week for 16 weeks, followed by weekly information for eight weeks. **Control**: mailed information focused on child development	BMI was significantly lower in the intervention group compared to control (-0.40; 95% CI: -0.79 to 0.00; p = 0.05). Compared with controls, sleep duration increased (0.75 hours/d; 95% CI: 0.06 to 1.44; p= 0.03), and TV viewing decreased (-1.06 hours/d; 95% CI: -1.97 to -0.15;p= 0.02)
Harvey-Berino and Rouke, 2003	43 mother child dyads 9 months –3 years old Home based Random allocation	**Intervention**: parent support plus obesity prevention (1hour/week home visit focused on diet and physical activity for 16 weeks (11 parenting lessons topics that were covered over 16 weeks (included information on diet and physical activity). **Control**: only received parental support	Children randomised to the intervention significantly decreased energy intake compared to controls (-316 (835) kcal/d v 197 (608) kcal/d; p<0.05).
Inglis et al., 2010	'*Mealtime Magic' program* obesity prevention in primary care 110 parents Children under the age of 5	Leaflet to encourage healthy feeding in young children with three verbal reinforcements of messages to (i) present foods up to 20 times to encourage familiarly, (ii) offer a wide variety of foods, (iii) avoid focusing child to eat all foods offered.	92% of parents found leaflet information useful, 52% reported more confidence regarding information and 37% reported positive behaviour changes.
Essery et al., 2008	*Mail correspondence* 93 mothers 2-5-year-old children Home based	(i) **Weekly 4-page newsletter** for 12 weeks (each containing 5 sections designed to discuss child feeding practise, and physical activity for preschool children), (ii) **52-page Booklet** (included all newsletter materials) (iii) **Control:** no information	No differences in feeding practices were observed, except the 'pressure to eat' score decreased in the newsletter group v control (2.5 (1.0) to 2.1(1.0); p<0.01).
McGowan et al., 2013	*Poppets Healthy feeding habits* 126 children aged 2-6 years Cluster RCT	**Intervention**: four home visits over eight weeks, parents received training (~1hr) on habit formation of three behaviours; serving fruit/vegetables, serving healthy snacks, and serving non-sweetened drinks. **Control**: no treatment group included information to improved healthy eating plus a supermarket voucher.	Intervention effects on children's intake of vegetables (Wald's F =28.5; p=0.003), healthy snacks (Wald's F =17.1; p=0.009), and water (Wald's F =8.7; p=0.032) at 8 weeks.
Wardle et al., 2003	*Parent-led exposure* 156 children aged 2-6-years RCT	Randomised after a pre-intervention taste test for 6 test vegetables (i) **Exposure** – repeated tasting of target vegetable for 14 days (ii) **Information** – nutrition advice and leaflet (iii) **Control** – no intervention	Exposure intervention increased liking, ranking and consumption of vegetable after 14 days (p<0.001).

Chapter 5 Rationale and Research aims

You must not only aim right, but draw the bow with all your might – Henry Thoreau

5.1 Overview of literature and rationale for the current research

Chapter 1 highlighted the prevalence of preschool overweight and obesity is rising globally, and is particularly affecting transitional societies, such as the UAE. The high prevalence of preschool overweight and obesity in the UAE and neighbouring countries confirms the need for future research to identify risk factors responsible for this growing problem. Identifying risk factors of preschool overweight and obesity is key, in order to tailor effective obesity prevention strategies. However, as shown in **Chapter 2**, most studies have been carried out in developed countries, and little is known about how these risk factors operate in transitional developing countries. Moreover, the systematic review (see section 2.4) found that the impact of preschool obesity risk factors is poorly understood in the Arabian Gulf region and no study to date has investigated the associations between risk factors and preschool obesity risk in the UAE.

The lack of research is clearly evident in relation to dietary risk factors. The role of diet in the development of preschool overweight and obesity is well recognised (**Chapter 3**), and therefore it is important that healthy dietary habits are established in early life. However, in the UAE, despite the changes in dietary habits following the nutrition transition, limited research has investigated associations between diet and childhood overweight and obesity, especially in preschool children.

Chapter 4 gave an overview of preschool overweight and obesity prevention interventions. However, based on the current literature available in the UAE and neighbouring Arab Gulf countries**,** the effectiveness of interventions in preventing the development of preschool obesity is unknown. As such, no intervention studies have been implemented to manage this public health issue in young children.

Therefore, the two key aims of this thesis are to identify obesity risk factors, and better understand how they influence the development of preschool overweight and obesity in the UAE. This thesis also aimed to investigate the effectiveness of a simple healthy lifestyle tool (Eat Right Emirates) in the prevention of preschool overweight and obesity in the UAE. The aims and hypotheses of each study included in this thesis are described below. These are divided into two parts: **Part A:** a cross-sectional study (includes Study 1 and 2), **Part B:** a randomised controlled trial (includes Study 3).

5.2 Aims and hypotheses

PART A

Study 1 aimed to: Describe putative risk factors for overweight and obesity in preschool children in the UAE, mainly exploring associations between developmental, behavioural and dietary factors with overweight and obesity.

Hypothesis 1

Longer duration of breastfeeding is associated with a lower risk of overweight and obesity in preschool children in the UAE.

Hypothesis 2

High birth weight is associated with an increased risk of overweight and obesity in preschool children in the UAE.

Hypothesis 3

Early introduction of complementary foods is associated with an increased risk of overweight and obesity in preschool children in the UAE.

Study 2 aimed to: Describe dietary intake, define dietary patterns in preschool children the UAE, and investigate associations between dietary factors with overweight and obesity.

Hypothesis 4

High relative energy intake, and contributing macronutrients, is associated with increased risk of overweight and obesity in preschool children in the UAE.

Hypothesis 5

Healthy dietary patterns are associated with a lower risk of overweight and obesity in preschool children in the UAE.

PART B

Study 3 aimed to: Investigate the efficacy of the Eat Right Emirates tool: a simple, healthy lifestyle tool (ERE) that aimed to encourage healthy eating and physical activity and reduce the risk of overweight and obesity in preschool children in the UAE in a single blind randomised controlled trial.

Hypothesis 6

The Eat Right Emirates tool reduces the risk of overweight and obesity in preschool children in the UAE.

Hypothesis 7

The Eat Right Emirates tool improves dietary intake of preschool children in the UAE.

Chapter 6 General Methods

The method of scientific investigation is nothing but the expression of the necessary mode of working of the human mind- Thomas Huxley

6.1 Introduction

This chapter reports the methods used in this PhD thesis for recruitment, randomisation and measurement of outcomes. This includes the collection of data using questionnaires, food diaries and statistical methods.

6.2 Study design

The current thesis includes two study designs. Methods relevant to each study are described in Part A and Part B of this chapter.

Part A: Cross-sectional study to identify risk factors of preschool overweight and obesity in the UAE (**Study 1** and **Study 2**).

Part B: A single blind (investigator) Randomised Controlled Trial to investigate the effectiveness of the Eat Right Emirates tool designed to encourage a healthy lifestyle and prevent preschool overweight and obesity in the UAE (**Study 3**).

6.3 Study population

Participants for both studies were recruited from a private school, Emirates National Schools (ENS) in the Al Ain district of Abu Dhabi, UAE, which enrolled 402 preschool-aged children between 2 and 6 years. Since the main focus of this thesis was to investigate risk factors for preschool overweight and obesity in a local population of Emiratis, this school was chosen because it enrolled a large percentage of Emirati nationals (97%) compared to other schools, which enrolled a large proportion of mixed nationalities.

6.4 Sample size calculation

There were no previous studies to guide sample size calculation (using a leaflet for obesity prevention). However, based on a previous study of an obesity intervention in our research group (Sacher et al., 2005), we expected to detect a

0.5 standard deviation difference in BMI z-score in randomised groups assuming 5% significance and 80% power. The minimum projected sample size was 128 subjects (64 in each randomised group), assuming 20% drop out, 72 children per group were required, making a total of 144 to detect differences in the primary outcome (BMI z-score).

6.5 Inclusion and exclusion criteria

Healthy children aged 2 to 6 years were eligible to participate in the study. Potential participants with a pre-existing clinically diagnosed medical condition were excluded, as these conditions may affect participation in the study.

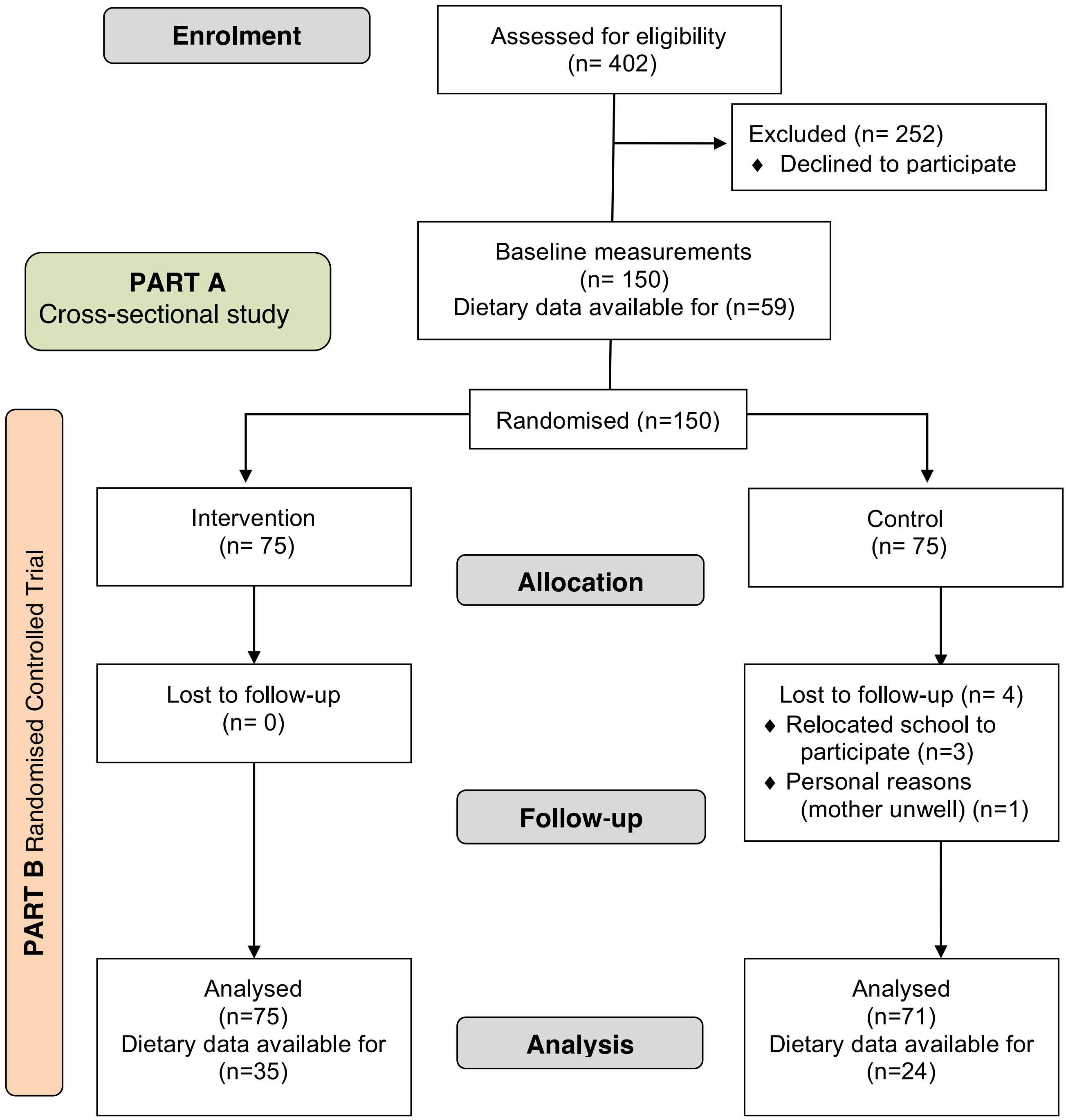
6.6 Ethical considerations

Ethical approval was obtained from both the Research Ethics Committee at University College London (Project ID: 5618/001, R&D Registration number: 14NT05, see **Appendix I**) and the the National Research Ethics Committee at the College of Medicine and Health Sciences, United Arab Emirates University (**Appendix J)** . Once ethical approval was attained, the Head of Kindergarten and School Principal were contacted and the study objectives were explained. Following the preschool's approval, permission to access participants' contact details and conduct the study at the Emirates National School was arranged. Arrangements were made within the school premises to carry out interview-based questionnaires with parents, and conduct non-invasive measurements.

6.6.1 Data protection

The researchers involved in the study were instructed to maintain the confidentiality of participants at all times. Study ID numbers were used in all data collection forms. Consent forms with information that identified participants were kept separate from all other documents, in a locked cabinet at the researcher's office in the United Arab Emirates University. A unique study ID number was used on data collection forms, including questionnaires, measurement forms and food diaries. Data were held in a locked building and department, on password-controlled computers, with each file password-protected to ensure full safety and security of information. All data collected (including data on computers) were identifiable by an ID number only. Data collection and storage procedures at the Childhood Nutrition Centre and United Arab Emirates University (Faculty of Public Health) are entirely compatible with the Data Protection Act (reference: No Z6364106/2014/04/17).

Figure 1 Study flow chart in accordance with CONSORT



6.6.2 Recruitment

A school administrator provided contact details of all children enrolled at the school. Parents were contacted prior to the study by a telephone call to explain the details of the study, and parents were invited to a briefing session at the school premises. At the briefing session, parents were provided with an invitation letter (**Appendix K**) and parent information sheets (**Appendix L**), explaining reasons for doing the study, the measurements involved and an overall explanation of the study protocol and procedures. Parents were advised to read the information provided carefully and freely ask questions. They were also advised to discuss the study with family and friends should they wish to take part. Parents were contacted at least 48 hours later to enquire whether they were interested in taking part. If parents wished to take part, an appointment was made during a pre-specified period (either a morning or evening period) to attend for screening at the school premises.

6.7 Informed consent

At the screening appointment, parents of potential participants were given the opportunity to ask questions about the study. Parents were informed that they were consenting to partake in a study that aimed to investigate risk factors of preschool overweight and obesity, as well as test the effectiveness of a simple healthy lifestyle tool that aims to encourage a healthy lifestyle and prevent overweight and obesity. If they agreed and met the inclusion criteria, parents willing to participate were then asked to sign a consent form giving permission for them and their child to participate (**Appendix M**). Parents of potential participants completed a questionnaire to ascertain whether they and their child were fit and able to take part in the study. Parents were provided with a copy of the consent form for their own records.

6.8 Data collection

Data was collected in the current thesis to complete the stated aims and test stated study hypotheses. Data from questionnaires and food diaries were completed by parents at baseline (PART A: measures used in Study 1 and Study

2), and after six months (PART B: measures used in Study 3) at the end of the intervention. I carried out all measurements at baseline and immediately after completing the intervention at 6 months, with some assistance from a trained assistant blind to the group allocation of participants. The research assistant was fully trained by myself in all procedures. Study outcomes are described in detail below, and summarised in Table 6-1.

6.8.1 Anthropometry

Height, weight, waist and hip circumferences of children were measured using standardised equipment and protocols (**Figure 6-1**). All measurements were carried out at the school nurse's office, and children wore light clothing.

6.8.1.1 Height, weight and BMI

Body weight was measured using electronic scales, accurate to 0.1kg (SECA instruments, Hamburg, Germany). Electronic scales were positioned on a levelled surface, and automated calibration was ensured before each measurement. Children were asked to remove their shoes and stand in the centre of the scales, facing forward with their hands on each side. The weight measurements were repeated three times and mean measurements were used in analyses.

Height was measured using a portable stadiometer, accurate to the nearest 0.1cm (Leicester portable height measure). Children were asked to remove their shoes and stand straight with feet flat and their back, shoulders, head and calves against the stadiometer backboard. Heels were placed against the heel plate and the head positioned in the horizontal Frankfurt plane. Children were asked to breathe normally and remain still until measurements were taken, by sliding the head plate on top of the child's head. Height measurements were taken three times and mean measurements were used in analyses.

Table 6-1 Outcome measures used in each study

	PART A		PART B
	Study 1	**Study 2**	**Study 3**
Child characteristics [1]	✓	✓	✓
Age			
Sex			
Anthropometric [2]	✓	✓	✓
Height (cm)			
Weight (kg)			
Waist circumference (cm)			
Hip circumference (cm)			
Mid upper arm circumference (cm)			
Body composition [3]	✓	✓	✓
Skinfold thickness (Biceps, Triceps, Subscapular, Supra-iliac (mm))			
Cardiovascular [4]			
Systolic blood pressure (mmHg)	✓	✓	✓
Diastolic blood pressure (mmHg)			
Resting heart rate (beats per minute)			
Socio-demographic, lifestyle and parental [1]			
Mother	✓	✓	✓
Age			
Ethnicity			
Educational level			
Occupation			
Marital status			
Weight and Height (reported)			
Father			
Age	✓	✓	✓
Educational level			
Occupation			
Weight and Height (reported)			
Lifestyle	✓		
Number of individuals living in household			
Domestic helper			
Smoking status			
Developmental factors [1]	✓		
Pregnancy and infancy			
Parity			
Birth order			
Birth weight			
Infant feeding	✓		
Breastfed, Never breastfed			
Duration of exclusive breastfeeding,			
Duration of any breastfeeding			
Duration of formula feeding			
Age of complementary feeding			

[1] Parent-reported questionnaires previously used in Trim Tots study (Lanigan et al., 2013).
[2] Measured using standard protocols, [3] Measured using callipers
[4] Measured using automated blood pressure machine
✓ indicates data used in study

	PART A		PART B
	Study 1	**Study 2**	**Study 3**
Diet [1]		✓	✓
Energy and macronutrient intake (carbohydrates, protein and fat)			
Dietary patterns (*a priori* diet score, *a posteriori* principal component analysis)			
Behaviour [2]			
Physical activity	✓	✓	✓
Activities played on a regular basis (e.g. riding bike, swimming etc.).			
Hours spent per week in vigorous physical activity			
Activity related behaviour score [3]	✓		✓
Sedentary behaviour			
Hours spent per week watching TV or playing video games	✓		✓
Sleep duration			
Hours of sleep per night			✓
Diet-related behaviour [3]			
Eating behaviour score			
Enjoyment of food score			
Appetite score			
Helping of fruit and vegetables			
Parental feedback on Eat Right Emirates tool[3]			✓

[1] Validated 5-day food diary
[2] Parent-reported questionnaires previously used in Trim Tots study (Lanigan et al., 2013).
[3] Using 10 point Likert scale
✓ indicates data collected in study

6.8.1.2 Defining child weight status: classification of overweight and obesity

Weight and height were used to classify weight status using the Body Mass Index (BMI) as a proxy, calculated using Quetelet's formula: body mass (kilograms) divided by height (metres).[2]

As previously discussed in Chapter 1, defining overweight and obesity in children is complex, because BMI varies with development (age), sex and ethnicity. Therefore, adult cut-off points (overweight BMI: ≥ 25 kg/m^2, obesity BMI: ≥ 30 kg/m^2) cannot be used. Instead, age, sex and population specific cut-offs are used with relevant reference data. For the current research, height, weight and BMI standard deviation scores (z-scores) were calculated using the WHO 2006 growth standard and WHO 2007 reference data in the LMS Growth macro for Microsoft excel (Cole, 2008).

Each child's BMI z-score was first calculated using the LMS formula

$$\text{BMI z-score} = \frac{(\text{observed value} + \mathbf{M})^{\mathbf{L}} - 1}{\mathbf{L} \times \mathbf{S}}$$

L denotes the power needed to transform the data in order to remove skewness
M denotes the reference median value which estimates the population mean
S denotes the coefficient of variation

Due to the wide age range of children included (2 to 6 years), overweight and obesity was defined using both the WHO 2006 growth standard and WHO 2007 reference data, according to the child's age. For children aged less than 5 years, overweight was defined as a BMI z-score greater than +2SD and obesity as a BMI z-score greater than +3SD on the WHO 2006 growth standard. For children over 5 years of age, the WHO 2007 reference was used, and overweight and obesity were defined using BMI z-scores greater than +1SD and +2SD respectively. This method was previously used in another study of 3- to 6-year-olds, which used the WHO 2006 and WHO 2007 cut offs accordingly to estimate the prevalence of overweight and obesity (Xiao et al., 2015).

The prevalence of overweight and obesity estimated using IOTF references using the LMS macro found that 11% of children in the study were overweight/obese, with moderate agreement with the prevalence estimated using the WHO 2006 and WHO 2007, as mentioned above (Cohen's Kappa: 0.7; p<0.001). Therefore, as the WHO 2006 growth standard was developed using growth data from Oman (a neighbouring Arab Gulf country), the WHO 2006 growth standard and WHO 2007 growth reference were chosen and the cut-offs to define overweight/obesity were used accordingly in the current study.

6.8.1.3 Waist, hip and limb circumference

Waist, hip and limb (mid-upper arm) circumferences were measured using a non-stretchable calibrated tape measure to the nearest 0.1cm. The narrowest girth of the waist approximately 4cm above the umbilicus was identified to measure waist. Children were asked to breathe normally, and measurements were taken at the end of normal expiration. Hip circumference was measured at the widest point.

All measurements were taken on the left side (or non-dominant arm) to achieve standardisation between measurements at baseline and follow-up. Mid-upper arm circumference (MUAC) was measured at the mid-point between the olecranon process (elbow) and the lateral tip of the acromion process (shoulder) with the child standing straight, with the left arm bent at an angle of 90^{o}. Once the mid-point was identified, the child was asked to stand with arms hanging loosely, and mid-upper arm circumference was measured. Points were marked for skinfold measurements.

6.8.2 Body composition

6.8.2.1 Measurement of skinfold thickness

Skinfold thickness measurements were taken to the nearest 0.2 cm at four standard sites: triceps, halfway between the acromion and the olecranon process at the back of the left arm; biceps at the same level on the front of the arm; sub-scapular skinfolds about 20mm below the tip of the scapula and supra-iliac 20mm above the iliac crescent, near the medial line using callipers (Holtain, Instruments Ltd) according to standard protocols. Each skinfold measurement was measured three times in order to reduce measurement error, and mean values were used for analyses.

Figure 6-1 Instruments used for anthropometric measurements

From clockwise: non-elastic tape, stadiometer, electric scales and callipers

6.8.3 Cardiovascular health

Resting systolic and diastolic blood pressure and resting heart rate were measured using an automated blood pressure monitor; with appropriately sized cuffs (Accuatorr Plus NIBP). Three measurements were taken on the left arm after the child had been sitting still for 10 minutes, and a mean value was recorded for analyses (Figure 6-2). It was not possible to measure supine blood pressure, as is often recommended, due to lack of facilities to lie down in the school premises.

Figure 6-2 Photos taken during data collection

Children displaying stickers used as a reward for completing measurements

Study investigator (DT) with study participant while blood pressure measurements were taken

6.8.4 Developmental factors

Data on pregnancy, birth weight and infant feeding practices were collected from mothers using questionnaires previously used in the Trim Tots study (Lanigan et al., 2013). Maternal recall using questionnaires has been suggested to be a valid and reliable estimate of infant feeding practices, especially when the duration of breastfeeding is recalled within the preschool years (Li et al., 2005). Mothers were asked to recall whether the child had been breastfed or not, the age when they completely stopped being fed breast milk, the age when they were first fed formula, the age when they completely stopped drinking formula, and the age they were introduced to solids (complementary feeding). Responses were used to calculate the duration of exclusive or any breastfeeding, and the duration of formula feeding, in months. Although most analyses were based on continuous data, the data was further categorised for dichotomous analysis. Birth weight was categorised as low (<2.5kg), normal (2.5kg-3.9kg), and high (>4.0kg), while breastfeeding was categorised into ever breastfed (yes, no), formula fed (yes, no), exclusive breastfeeding for 4 months or 6 months (yes, no), duration of any breastfeeding (never, less than 2 months, 3-5 months, more than 6 months), and age of complementary feeding (before or after 4 months).

6.8.5 Socio-demographic measures

6.8.5.1 Educational status

The educational status of parents was categorised according to whether they attained a university degree. For the current research, the mother's educational level (with degree, without degree) was chosen to represent educational level.

6.8.5.2 Social Class

Social class was determined based on the occupation of the father. In the UAE, there is no distinct categorisation of social class (National Bureau of Statistics, 2011). Therefore, a dichotomous division (manual, non-manual) was used to allow for comparisons with previous research.

6.8.6 Parental factors

Data on parents' marital status (married, divorced), maternal ethnicity (Emirati, non-Emirati), mother's age (years), father's age (years), domestic helper employment (yes, no) were collected using questionnaires.

6.8.6.1 Lifestyle and smoking

Parental smoking practice information was also collected. In the UAE, in addition to smoking cigarettes, '*shisha'* (hookah) and *'medwakh'* (a smoking pipe) are integrated within the culture among men. Women are not regarded as smokers. However, both parents were asked if they smoked (yes, no) and duration of smoking was documented.

6.8.6.2 Parental overweight and obesity

Self-reported height and weight of parents were collected using questionnaires, and BMI was calculated. Parents' BMI between 25 and 29.99 kg/m^2 was classified as overweight and a BMI above 30 kg/m^2 was classified as obese (World Health Organisation, 2000).

6.8.6.3 Mother's perception of weight status

Each mother's perception of weight status was obtained from questions about their child's weight status ('Do you consider your child is at a healthy (normal) weight?' 'Do you think your child is overweight?', 'Do you think your child is underweight?'). The mother's responses were categorised into 'underweight', 'normal weight' and 'overweight/obese'.

6.8.7 Dietary assessment

6.8.7.1 Food diaries

The parents of participating children were asked to record all food and drink items consumed over five days using food diaries validated for use in preschool children (Lanigan et al., 2013). The parents were shown how to adequately fill out food diaries. They were specifically asked to specify meal, day of consumption, amount offered, brands, cooking methods and amount left over.

Five day food diaries (two days on the weekend, and three days within the week) were chosen, as they provide accurate estimates of dietary intake, and can be used to assess dietary patterns of preschool children (Emmett et al., 2015). However, in this age group, fewer days are needed to estimate energy and macronutrient intake; therefore, diaries that included at least three days were included in analyses (Lanigan et al., 2001). Food diaries allowed both quantitative and qualitative assessment of dietary intake, and were not dependent on accurate recall. Parents were advised to record all meals, snacks and drinks consumed. An example day was adapted to provide an example of a Middle Eastern diet, and an example recipe for a commonly cooked chicken and rice dish (Machboos) was given for guidance. Pictures of household measures were used as examples within the food diary (e.g. teaspoon, tablespoon etc.) to aid reporting of different portions of food served. Parents were asked to provide recipe information for homemade dishes and were requested to note the brand of any food item consumed (e.g. juice type 'Lacnor') (**Appendix N**). Food diaries were checked to ensure information provided was clear and sufficient. In cases where parent's responses were vague or reported food intake was doubtful, I clarified these responses. For instance, in the UAE and like many other Arab and Asian cultures, it is customary to eat certain foods (e.g. rice) using their hands. Therefore, in such situations where parents reported handfuls of foods, parents were called back to quantify the portion size in relation to household utensils.

6.8.7.2 Deriving dietary variables for analysis

The five-day food diary was used to estimate dietary intake and derive dietary patterns.

6.8.7.2.1 Coding of dietary data

Food and beverage intake were coded and entered into the dietary analysis program *Microdiet* (Downlee systems Ltd, Derby, UK), which is an integrated system for dietary data entry and nutrient analysis of dietary intake. Food diaries were quality checked for completeness. If there was a large amount of missing dietary data within a diary (e.g. only provided dietary intake for one day), the food diary was excluded from analyses. All dietary data was converted to food groups and nutrient data using Microdiet software based on food composition data from the 6th edition of McCance and Widdowson's composition of foods (Food Standards Agency, 2002). Food items for which data on the food composition data were not available, were manually inputted using food composition data produced by Musaiger (2011a) for Middle-Eastern foods items. I performed dietary data entry, to ensure that food selection matched food recorded as accurately as possible.

Microdiet quantified foods eaten as part of composite dishes (e.g. those that included more than one component), and discrete portions, such as a banana. Composite foods were disaggregated into main food components (e.g. meat, fish, cheese, fruits, and vegetable), which were further broken down into sub-categories (for example, poultry is divided into chicken, turkey etc.). Disaggregating composite foods into their single food components allowed a more complete estimate of intake at the individual food level.

6.8.7.2.2 Energy and Nutrient intakes

Dietary intake was derived for each child, averaged over three days from diet diaries. Daily intakes of macronutrients (carbohydrates, protein and fat) were calculated as grams per day (g/d). The percentage of total energy intake (%E) from each macronutrient was calculated using the Atwater conversion factors: carbohydrate (3.75 kcal/g), protein (4 kcal/g) and fat (9 kcal/g)(Food Standards Agency, 2002). The number of grams of each macronutrient was multiplied by the amount of energy found in one gram of each macronutrient (Maclean et al., 2003). This produced the total energy in each macronutrient per day, which was then divided by the daily energy intake and multiplied by 100. Energy and macronutrient intake were also calculated relative to body weight (kcal or gram per kilogram body weight per day).

6.8.7.2.3 Under-reporting

Food diaries used in current study have been validated against weighed food records and doubly labelled water in children (Lanigan et al., 2001) and are particularly useful in populations that lack culturally-specific and validated dietary assessment methods e.g. FFQs and population specific food lists. However, this method only provides a snapshot of usual diet, and like other methods of dietary assessment (see Tables 3-1 and 3-2), the accuracy of dietary data collected is highly dependent on the parents' ability to correctly record foods and drinks consumed. Although efforts were made to ensure parents were provided with adequate portion size information to help standardise reporting of foods, variability is highly expected given the time-consuming process of completing the diaries, the dietary data is prone to reporting errors (see section 3.2.3) (Livingstone et al., 2000). Therefore, in assessing whether actual reported energy intake of children matched estimated energy requirements (EER) under-reporting was estimated. Upper and lower plausible levels of both energy intake and EER were also calculated by deriving the 'coefficient of variation' (CV_t) which allows for variation in the estimation of both energy intake and EER. These steps are described below.

Step 1: EER was calculated using quadratic regression analysis of Total Energy Expenditure (TEE) on weight, plus allowance for energy deposition in tissues during growth (Eg) taken from Torun (2005): **EER = TEE + Eg.**

Calculations were based on TEE predicted with quadratic equations from median body weight at the midpoint of each year of age. Given the age of the study sample, energy requirements of healthy, well-nourished children with 'average' levels of physical activity were calculated for children aged 4-4.9.

For boys: TEE (kcal/ day) = 310.2 + 63.3kg – 0.263kg^2
For girls: TEE (kcal/ day) = 263.4 + 65.3kg – 0.454kg^2

Eg= mean weight gain calculated using WHO references of weight by age (World Health Organisation, 1983; Torun, 2005). Given the mean age of children in the present study was 4.4 years, mean weight gain of girls (4.7 g/d) and boys (5.5 g/d) aged between 4-4.9 years was used.

Eg = 5.1 grams per day * 8.6 kJ/g or 2 kcal/g weight gain

Step 2: The coefficient of variation (CV_t) of EI/EER was calculated using the below equation derived from doubly-labelled water methods (Black and Cole, 2000).

$$CV_t = \sqrt{CV_{TEE}^2 + \frac{CV_{EI}^2}{d}}$$

CV_{TEE}^2 = CV for measurement of TEE (=19.1%, based on dietary studies of EER from Torun, 2005).

CV_{EI}^2= CV for measurement of EI (=15.5%, calculated by dividing the mean EI by standard deviation for each child).

d = number of food diary days (d=3)

CV_t **= 21.1%**

Based on these calculations, energy intake reported between 78.9 % and 121.1% (i.e. 100% plus or minus 21.1%) of EER was considered to be within the normal range of measurement errors, and were classified as ‘plausible reporters’. Children with an energy intake below 78.9% were classified as ‘under-reporters’ and those with an energy intake greater than 121.1% were classified as ‘over-reporters’. The percentage of plausible, under and over reporters in the current study population is shown in Table 6-2. Overall, most (83%) children were found to be plausible reporters. However, 5% under-reported, and 12% over-reported, suggesting that there is some reporting error, which needs to be considered when interpreting dietary data in this thesis.

Table 6-2 Percentage of reporting categories in the study sample (EI/EER)

	n	Under reporters	Plausible reporters	Over reporters
All sample	59	5	83	12
Boys	37	3	54	3
Girls	22	0	29	9

6.8.7.2.4 Comparisons with Dietary Reference Values

To assess the adequacy of energy and nutrient intakes, the UK Dietary Reference Values (DRVs) were used, which are age and sex specific. In order to assess adequacy of intake, multiple criteria were employed. Average daily energy intake was calculated as a percentage of the 2011 Scientific Advisory Committee on Nutrition (SACN) Estimated Average Requirement (EAR) for children, according to their age at dietary intake collection (Scientific Advisory Committee on Nutrition, 2011). Protein intake was calculated as a percentage of the Department of Health Reference Nutrient Intake (RNI) for children aged between 4 and 6 (Department of Health, 1991). Carbohydrate and fibre intake were compared with the SACN (2015) recommendations for children aged between 2 and 5 years old (Scientific Advisory Committee on Nutrition, 2015). Fat intake as a percentage of energy was compared with the COMA 1991 recommendations for children aged 5 years and above (Department of Health, 1991).

6.8.7.2.5 Methods used to derive dietary patterns

Dietary data collected using food diaries were exported to Microsoft Excel, and food groups were used to derive dietary patterns. In the current study, two methods were used to derive dietary patterns: (i) an *a posteriori* approach data-driven method using principal component analysis. Principal component analysis was chosen in comparison to other methods because: (i) principal component analysis is the most common method used to derive dietary patterns of young children (Ambrosini, 2014); (ii) based on previously published studies deriving dietary patterns of young children, it has been suggested that PCA may generate more meaningful and interpretable dietary patterns compared to cluster analysis (Kant, 2004; Newby and Tucker, 2004); (iii) cluster analysis derives dietary patterns based on differences in dietary intake between individuals that are separated into two mutually exclusive clusters (i.e. individuals are assigned to only one cluster), and therefore, it has been suggested that cluster analysis has a lower statistical power, and is highly influenced by extreme values, compared to PCA (Schulze and Hoffmann, 2006; Moeller et al., 2007); (iv) since no previous study has identified dietary patterns of preschool children in the UAE and neighbouring Arabian Gulf countries, PCA was chosen because PCA-derived dietary patterns are found to better describe the actual dietary patterns of the population of interest, and therefore have greater public health relevance.

(*ii)* an *a priori* approach using diet quality score developed for international use (Voortman et al., 2015) (see section 3.4)

6.8.8 Behavioural measures

A questionnaire that has been previously used in the Trim Tots study: an intervention for preschool obesity (Lanigan et al., 2013) (**Appendix O**) was used to collect data on general behaviour, sleep duration, activity-related behaviour, physical activity, sedentary behaviours and diet-related behaviours.

6.8.8.1 Physical activity and sedentary behaviour

The questionnaire included the number and duration of periods of physical activity spent on different vigorous activities, and sedentary activities (e.g. television, electronic games). Parents were asked to provide information on the following through the questionnaires: (i) type of activities their child takes part in (e.g. cycling, trampoline, swimming, walking, dancing etc.); (ii) the duration of vigorous activity (defined as an activity that leads to the child getting out of breath or sweating) per week; (iii) the number of hours per week their child spent watching TV and playing video games during the week and weekend.

Physical activity was measured as hours per week, and categorised into dichotomous variables (more than 3 hours/less than 3 hours of moderate to vigorous physical activity per day) in line with physical activity recommendations for preschool children in the UK. Sedentary behaviour was measured as hours spent watching TV (screen time) or playing video games per week, and categorised into dichotomous variables (more than one hour per day/less than one hour per day).

6.8.8.2 Sleep duration

Sleep duration was measured as hours of sleep per night. Parents were asked to report how many hours their child slept at night in hours (‘4 – 5’, ‘6 – 7’, ‘8 – 9’, ’10 – 11’, ‘more than 12 hours’), and for analysis the average of hours of sleep per night was calculated. Although there are currently no recommendations to define short sleep in early childhood, sleeping less than 11 hours per night has been found to be associated with an increased risk of obesity (Chen et al., 2008). Therefore, sleep duration was also dichotomised as sleep <11 hours per night, or >11 hours per night for children under the age of 5.

6.8.8.3 Child’s behaviour score

A questionnaire previously used in the Trim Tots study (Lanigan et al., 2013), which also included several questions from the validated Child Eating Behaviour Questionnaire (CEBQ) (Wardle et al., 2001; Lanigan et al., 2013), designed to evaluate general eating behaviour in preschool children, was used to measure general activity and diet-related behaviours using a 10-point Likert scale (**Appendix O**). Parents were asked to rate each behaviour related item. Each item had a possible score of 1 to 10, where a higher score denoted positive improvements. A high score for the following scores indicates, for general behaviour (mood): a *child is happy, does not get upset easily and is communicative*; for activity-related behaviour: a child is *active, energetic, and plays a lot;* for eating behaviour: a child is *easy to feed, calm during meals, pays attention to meals and eats slowly*; for enjoyment of food: a child *enjoys meals, enjoys tasting new foods, enjoys a wide variety of foods, enjoys vegetables, enjoys fruits*. However, a high appetite related score indicated that a child has *a big appetite, is not full before finishing, always asking for food.* Therefore, these scores were reversed for analysis.

Parents were also asked to report the daily frequency (‘0-1 times’, ‘2-3 times’, ‘4-5 times’, ‘more than 5 times’), that their child had each of the following: helpings of fruit and vegetables, types of fruits and vegetables, snacks, within the past two weeks. For analysis, the average of the scores was used.

PART B: Randomised Controlled Trial

The ‘Eat Right Emirates’ (ERE) study was a single blind randomised controlled trial conducted in Al Ain, UAE between September 2014 and June 2015. The study was a collaboration between the Childhood Nutrition Centre, UCL Great Ormond Street Institute of Child Health and the United Arab Emirates University (UAEU) Department of Medical and Health Science, Faculty of Public Health. The study is registered with ClinicalTrials.gov (Trial number: NCT02559076).

Baseline measurements carried out in October 2014 (**Part A**) were used to identify risk factors of preschool overweight and obesity in the UAE in a cross-sectional study design. The same subjects were recruited to be part of the randomised controlled trial, and at six months from baseline, anthropometric, socio-demographic, cardiovascular, behavioural and dietary data were assessed to investigate the effectiveness of a simple healthy lifestyle tool, Eat Right Emirates.

6.9 Randomisation

Participants were randomised using a computerised permuted block design with blocks of size 2 and 4. A research assistant was responsible for assigning participants to either control (usual care) or intervention group, in order to blind investigators (myself and a trained research assistant) carrying out the study measurements from the randomisation and group allocation. Participants were instructed not to reveal their assigned group to the researchers performing the measurements. Allocation to randomised groups was by opaque envelopes labelled with participant ID numbers. Each envelope enclosed materials for either intervention or control, and food diaries labelled with participant ID number, to ensure standardisation.

6.9.1 Intervention

Participants randomised to the intervention group received a simple informative leaflet: The Eat Right Emirates tool, adapted from the Ten Steps for Healthy Toddlers developed by the Infant and Toddler forum in the UK (www.infantandtoddlerform.org) (see section 4.4.2.1). The Infant and Toddler Forum produced the Ten Steps for Healthy Toddlers leaflet as a consensus document from an expert group of health care professionals (paediatricians, dietitians, health visitors and psychologists). The leaflet was based on current government advice, existing evidence on toddler nutrition, and expert opinion. The Ten Steps for Healthy Toddlers document provides consistent, simple and sound nutritional advice that can be applied wherever toddlers are fed, in order to achieve good habits for health, growth and development. The leaflet provides parents/carers with ten easy to follow steps highlighting positive strategies to cater for a toddler's nutritional needs, and ensure positive attitudes towards food and exercise (**Appendix Q)**. These steps and the evidence behind them are summarised in **Appendix G.**

The practical and simple guide provides clear educational steps for parents, and includes information on foods to offer, advice on managing meal times and fussy eaters, and is accompanied by a guide highlighting the five food groups, with portion size examples to guide parents. These steps broadly focus on authoritative parenting styles and child-feeding practices (i.e. parents are advised to encourage eating using supporting and non-directive behaviours; nurturing and high in structure; demanding, but responsive to children's needs) (see section 3.3.3.1). For instance, *Step 1* advises parents to 'praise your toddler when he or she eats well, or tries something new'; *Step 2* and Step 7 advise parents to avoid pressuring their child to eat; 'never insist your child eats everything on his or her plate' and 'respect your toddler's tastes and preferences – don't force feed'; and *Step 8* advises parents to 'reward your toddler with your attention – never give food or drink as a reward, treat or for comfort'. Other steps include information on foods to offer, appropriate portion sizes, and guidelines for physical activity, sedentary behaviour and sleep, which have been suggested to influence obesity risk in children (see Chapter 2 and 3).

6.9.1.1 Choosing Ten Steps for Healthy Toddlers as the intervention tool

As reviewed in earlier chapters, evidence-based information regarding toddler nutrition is scarce in the UAE and neighbouring Arab Gulf countries. Also, the lack of previous research on preschool obesity in the Emirates limits the evaluation of earlier intervention studies (see Chapter 4, section 4.5). However, it is evident from a previous intervention in the region (Boodai et al., 2014), that cultural restraints, low compliance, low level of nutrition-related knowledge and lack of awareness among parents hinders participation in such intervention studies.

Earlier parent-focused educational interventions (e.g. mealtime magic, see section 4.4.2), have found that parents receiving leaflets (to encourage healthy eating) were rated as 'valuable' and 'useful' (Inglis et al., 2010). Similarly, social marketing campaigns providing mnemonic advice on diet and physical activity (e.g. Lets go! 5, 2, 1, 0, see section 4.2.2.1) reported that parents were highly receptive and the consistent messages increased parental awareness (Rogers et al., 2013). In view of these findings, and because there is currently no evidence-based advice on healthy eating during the preschool years in the UAE and neighbouring Arab Gulf countries (Musaiger et al., 2011; Al Junaibi et al., 2013). The Ten Steps for Healthy Toddlers leaflet was chosen as an appropriate tool for reducing obesity risk, in a population that has not been previously exposed to information promoting a healthy lifestyle for toddlers.

6.9.2 Adapting the Infant and Toddler Ten Steps for a Healthy Lifestyle to develop the Eat Right Emirates healthy lifestyle tool

Before the use of the Ten Steps leaflet, certain modifications were made to adapt it for the UAE population and increase acceptability. The leaflet was renamed as ‘Eat Right Emirates: Ten Steps for a Healthy Toddlers’, and all included information was translated into Arabic. Food items used in the five-food guide were also culturally adapted and modified to suit the Middle Eastern diet. For example, foods commonly consumed by children in the UAE were added to each food group. Chapatti, pitta bread and vegetable/cheese samousa were included in the starch (bread, rice, potatoes and pasta) foods group. Vegetable soup was added to the fruit and vegetables group. Mahalabiya a more familiar milk based dessert consumed by children in the Middle East was given as an example for milk puddings. In the protein group (meat, fish, eggs, nuts and pulses) examples of meats (e.g. kebabs), composite dishes (e.g. chicken machboos) were given, and other foods were translated to in their Arabic names (e.g. Hummus, Nukhi, Falafel for chickpea-based dishes) to increase familiarity (**Appendix Q**).

6.9.3 Control

Participants randomised to control (usual care) received a general health promotion leaflet for children provided by the Health Authority Abu Dhabi, which is part of the HAAD (Health Authority Abu Dhabi, 2011)(**Appendix R**).

To maintain blinding for myself, a research assistant trained by me explained each of the ten steps to parents receiving the ERE tool. Each point was discussed with mothers at baseline, and a research assistant called the parents twice within the 6-month period to ensure that they were still using the ERE tool and to answer any questions they had. The control group also received similar phone calls

6.9.4 Parental observations and feedback on the Eat Right Emirates tool

Parents' observations following the intervention were assessed using questionnaires previously used in the Trim Tots study (Lanigan et al., 2013) (**Appendix P**). Parents in the intervention group were asked to rate the overall usefulness of the Eat Right Emirates tool using a 10-point Likert scale from 'not useful' to 'very useful', where a high score indicates that parents found the intervention very useful. Parents were also asked to provide comments on the Eat Right Emirates tool; 'quotations' provided greater insight on the effectiveness of the intervention.

6.10 Statistical analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS) version 24 (SPSS Inc, Chicago, IL). In all studies, descriptive statistics were used to report mean and standard deviations for continuous data, and frequency statistics were used to calculate numbers and percentages for categorical variables. The normality of continuous data was assessed using a Q-Q plot, histogram and was also tested using the Kolmogorov-Smirnov test. Only skinfold thickness data were not normally distributed and therefore were $\log_e$ transformed and then multiplied by 100 prior to analysis. The mean of $\log_e$ transformed data represents a geometric mean and the standard deviation of the 100 $\log_e$ transformed data represents the coefficient variation (Cole, 2000). Statistical significance was set at $p < 0.05$ for all analyses. Statistical analyses for each study are described below.

PART A: Cross-sectional study at baseline

6.10.1 Study 1: Statistical plan to investigate risk factors of preschool overweight and obesity in the UAE (Chapter 7)

Characteristics of the study sample (socio-demographic, parental, anthropometry, cardiovascular health, and lifestyle behaviours) were examined. An independent t-test was used to compare continuous variables and chi-squared was used to compare categorical variables. Frequency analyses were carried out to determine the percentages of mothers who considered their child to be ‘underweight’, ‘normal weight’ or ‘overweight/obese’. Cross-tabulation with Cohen’s Kappa statistics was used to measure agreement between each mother’s perception of their child’s weight status and child’s actual weight status and estimate mother’s misperception.

6.10.1.1.1 Assessment of the associations between risk factors and BMI z-score (primary outcome) or overweight/obesity risk

The current study examined associations of risk factors with two outcomes at baseline: (i) BMI z-scores analysed on a continuous scale using linear regression; (ii) Child weight status dichotomised into not overweight/obesity and overweight/obese was analysed using logistic regression.

Linear regression was used to investigate associations between socio-demographic variables and BMI z score. Any variables that reached significance or presented a notable trend in the univariate analysis were also added into the multivariate analysis as confounders.

A full model was developed where risk factors (socio-demographic, parental, infant feeding practices and behavioural factors) and potential confounding factors (age, sex, mother’s BMI, father’s BMI, maternal educational level, social class and mother’s age) were entered simultaneously. Confounding variables included in the model were selected based on existing knowledge of confounders influencing obesity risk factors, and findings of previous analyses. A beta coefficient with 95% Confidence Intervals (CI) was calculated to identify variables associated with BMI z-score.

Logistic regression models were used to identify significant predictors of overweight and obesity as a categorical variable (not overweight/obese vs. overweight/obese). Models were first run separately for each factor, followed by multiple logistic regression models. All models were adjusted for factors known to influence outcome (age, sex, mother's BMI, father's BMI, maternal educational level, social class and mother's age). An Odds Ratio (OR) with 95% Confidence Intervals (CI) was calculated to identify variables associated with overweight and/or obesity.

6.10.1.2 Study 2: Statistical plan to investigate associations between diet of preschool children and obesity risk in the UAE (Study 8).

6.10.1.2.1 Describe dietary intake of preschool Emirati children

Baseline characteristics were compared in those returning (completers) and not returning (non-completers) food diaries. Independent samples' t-tests were used for continuous variables and chi-squared tests for categorical variables. Daily energy and macronutrient (total carbohydrate, sugars, fibre, starch, fat, saturated fat and protein) intakes were calculated as an average over the three days of food diary entries. Energy and macronutrient intakes were summarised as total grams per day (g/d), as a percentage of energy intake (%E), and relative to kilogram body weight (kcal/kg/d or g/kg/d). Descriptive analyses were calculated for all dietary intake data, including mean, standard deviation 25th and 75th percentile. To assess the adequacy of energy and macronutrient intake of study sample, dietary intake was compared with UK Dietary Reference Values (DRVs) using one-sample t-tests (see section 6.8.7.2).

6.10.1.2.2 Assessment of associations of energy and macronutrient intake with BMI z-score (primary outcome) and overweight/obesity risk

Linear regression was used to investigate associations between energy and macronutrient intake with BMI z-score. A full multivariate model was developed with dietary intake (energy and macronutrient intake) and potential confounding factors that were identified using univariate analysis. These included age, sex, mother's BMI, father's BMI, maternal educational level, social class and mother's age. Logistic regression was used to investigate associations between energy and macronutrient intake with overweight/obesity. Because of the small sample size, analyses were limited to univariate (unadjusted) analyses.

6.10.1.2.3 Deriving *a posteriori* dietary pattern using Principal Component Analysis

Principal component analysis (PCA) is a multivariable statistical technique, used to reduce a complex dataset of many components into a smaller set with fewer variables by dimension reduction (Kirkwood and Sterne, 2010). Therefore, PCA identifies linear combinations of the original observed variables on the basis of a correlation matrix that accounts for most of the total variance in the data. Coefficients of variation, which are used to define linear combinations, are called 'factor loading' and represent correlations of the variables in the original data. Orthogonal varimax rotation was used to improve interpretability and minimise the correlation between factors.

A large or high factor loading indicates that a variable is strongly associated with its component. Hence, the first component extracted using PCA accounts for most of the variance in the sample, and successive components explain the remaining variance. Each factor extracted is also independent of others derived using PCA. Several methods have been proposed to extract the optimum number of components. The Cattell Scree test (Cattell, 1966) and the Kaiser rule (Kaiser, 1960) are the most common procedures used to determine the number of components. Both of these methods inspect the correlation matrix eigenvalues. Eigenvalues are calculated as the sum of each squared factor loading for a given component. Using the scree plot, Cattell recommends that components above the infliction point on a plot of eigenvalues can be used as a cut point to set the selections of components based on trailing of factors as shown by the arrow in Figure 6-3.

Dietary data collected using food diaries were used to derive dietary patterns using PCA. Food items were grouped into 31 food groups based on: (i) similarity of food type (e.g. flavoured milk and semi-skimmed milk were grouped with whole milk to make up the milk food group); (ii) nutrient composition (e.g. candy, chocolate bars, fruit gums, lolly-pops etc. were grouped into the ‘confectionary’ food group); (iii) relation of certain foods found to increase obesity risk (e.g. chicken nuggets and fried fish fingers, and processed foods and meats were grouped separate to other lean meats, and fish/poultry); and (iv) common usage (e.g. cucumbers were included as a separate food since cucumbers are commonly consumed as snacks in this population, therefore the inclusion of cucumbers in the salad vegetables group may have intensified the influence of the ‘salad vegetables’ food group) (see, Table 6-3) (Fisk et al., 2011); and (v) foods and beverages relevant to the Middle Eastern diet were not categorised into food groups, because they were thought to reflect specific dietary habits relevant to the study population (e.g. *chai karak:* a delicacy drink made from tea and condensed milk). These were included as separate food items. The sum of foods and beverages within each of the 31 food groups was calculated to provide the daily consumption in grams.

The Kaiser-Meyer-Olklin (KMO) test and Bartlett’s sphericity test were used to measure the adequacy of the sample before factor analysis. KMO values greater than 0.50 and p-value less than 0.05 for Bartlett’s sphericity test were considered acceptable (Hair et al., 1998). Factor loading scores of the foods or food groups were calculated, and the percentage of variance explained by the factor loadings for each rotation method was estimated. PCA was carried out to identify the main dietary patterns from the included food items. The sum of daily consumption in grams of each food group was entered in the PCA. The first PCA on the 31 food groups produced a scree plot of eigenvalues of the derived factors, as described earlier. Three factors were retained for further analysis, based on the scree plot (Figure 6-3). The three derived factors were used in the PCA to derive factor loadings that would allow the interpretation of dietary patterns. The size of the factor loading for a food group within a component characterises its contribution to the dietary pattern.

Foods or food groups with factor loadings of more than 0.2 and less than -0.2 were considered to contribute to the component or dietary pattern (see, Table 6-4). A large factor loading (greater than 0.2) identified a greater contribution of a particular food group to a specific dietary pattern, whereas a large negative factor loading (greater than -0.2) identified a lower contribution of a particular food to that dietary pattern. i.e. the higher the score the closer the diet of the individual conforms to the dietary pattern, and the lower the score the further the diet is from the dietary pattern.

Three dietary patterns were identified. The first dietary pattern '**traditional/health-conscious**' was characterised with a high daily intake of fruit, vegetables, soup, vegetable curries, mixed Arabic dishes, fried rice, *chai karak,* Arabic pastry (chapatti), and breakfast cereals. The second dietary pattern **'Western/processed'** had high factor loadings for low fibre breads, fats, poultry/fish, meat products, processed foods, crackers/crisp bread, sweetened drinks and puddings. The third dietary pattern **'convenience/snack'** was characterised with a high daily intake of milk products, eggs, breakfast cereals, Arabic pastry, sweet spreads, mixed Arabic dishes, fried fish/poultry, fried potato, crisps, crackers/crisp bread and puddings.

A merged table consisting of the food group frequencies and factor scores was constructed and quintiles according to dietary pattern scores were calculated. Quintiles were calculated using cut points for five equal groups using the frequencies command, and new variables were created using the transform command. Subjects were classified into quintiles of adherence to each of the three dietary patterns identified.

Figure 6-3 Scree plot for principal components analysis of dietary data collected using food diaries

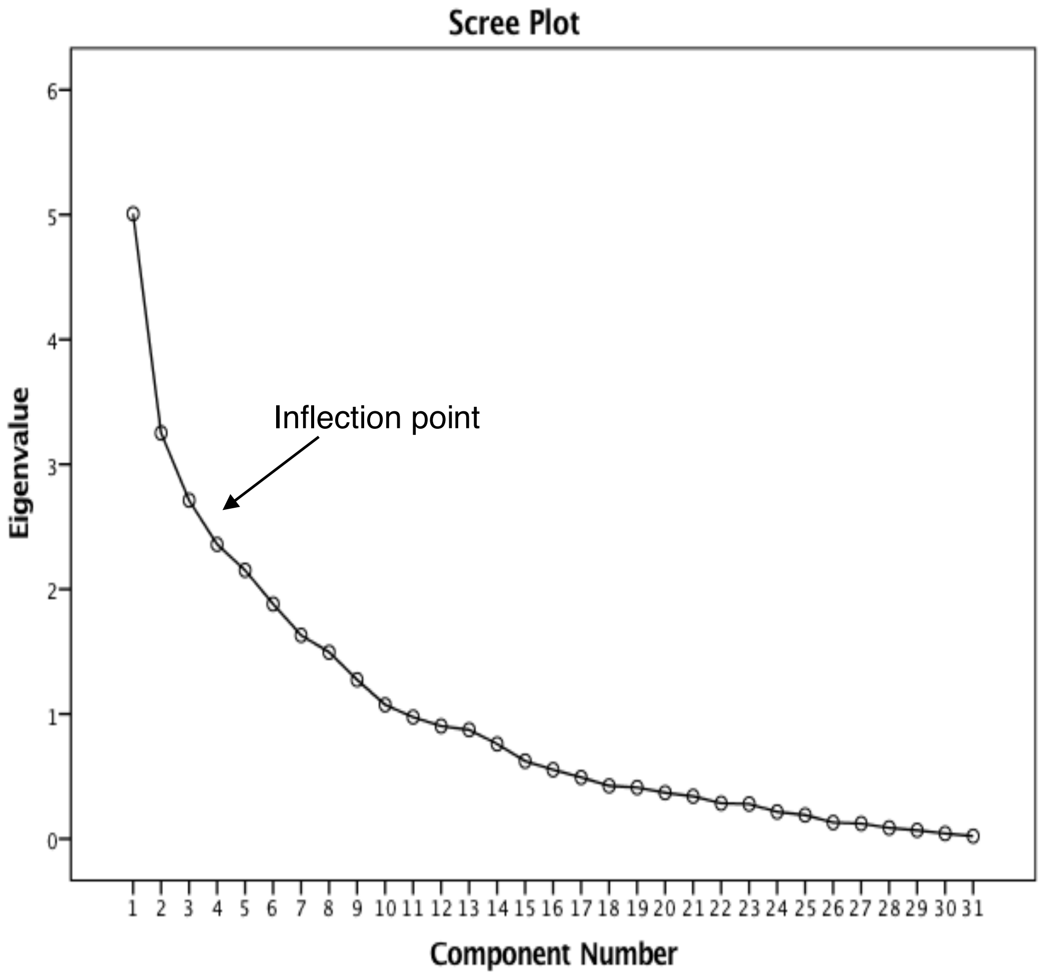


Table 6-3 Food items and food groups used to derive dietary patterns using principal components analysis

	Food or Food group	Food
1	**Milk**	Full-fat milk, semi-skimmed milk, flavoured milk
2	**Dairy products**	Yoghurt (flavoured and plain), cheese (hard cheeses, soft cheeses), buttermilk *(laban)*
3	**Eggs**	All types of eggs (scrambled, boiled, plain omelette)
4	**Breakfast cereals**	Ready-made cereals (Frosties, Coco Pops, Cheerio’s)
5	**Arabic pastry bread**	Chapatti, paratha
6	**Low fibre bread**	Rolls, toast, pitta, naan,
7	**High fibre bread**	Whole grain, rye bread
8	**Fats**	Olive oil, margarine, ghee, butter
9	**Sweet spreads**	Honey, jam, chocolate spread
10	**All fruits**	Apples, watermelon, grapes, melon, mango, bananas
11	**Cucumber**	Cucumber
12	**Salad vegetables**	Lettuce, tomato
13	**Other vegetables**	Sweet corn, peas, carrots
14	**Soup**	Tomato soup, vegetable soup, lentil soups
15	**Legumes**	Lentil stew, chickpeas
16	**Mixed Arabic dish**	Vine leaves, savoury dumplings, savoury oats (hares)
17	**Starch**	Plain rice (boiled), pasta, noodles
18	**Fried rice**	Fried rice, pilaf
19	**Poultry, fish**	Any type of fish or poultry (chicken, turkey, pigeon)
20	**Fried fish, poultry**	Fried fish, chicken in breadcrumbs
21	**Red meat**	Biryani meat, stewed meat (lamb, veal, beef)
22	**Processed food**	Chicken nuggets, pizza, burgers, hotdogs
23	**Fried potato**	French fries, fried croquets, hash browns
24	**Savoury snacks**	Pretzels, crisp bread sticks, popcorn
25	**Crisps**	Puffed potato, potato crisps
26	**Confectionery**	Sweets (fruit gums), chocolate bars, lolly pops
27	**Biscuits**	Cookies, digestives (plain or with chocolate)
28	**Savoury sauces**	Ketchup, mustard, mayonnaise, brown sauce
29	**Sweetened drinks**	Fruit juices from concentrates, fizzy drinks (Pepsi, sprite)
30	***Chai karak***	Black tea with condensed milk
31	**Pudding**	Bread and butter pudding, cake, ice cream, cakes, waffles, *luqaimat* (Arabic sweet dumpling), rice pudding

Table 6-4 Factor loading of dietary patterns from principal component analysis

Food or Food group		Dietary pattern		
		Health conscious/ traditional	**Processed/ Western**	**Convenience/ Snack**
% Variance		16.2	10.5	8.7
1	Milk	-0.040	**-0.207**	**0.231**
2	Dairy products	0.143	**-0.256**	0.136
3	Eggs	-0.117	0.058	**0.548**
4	Breakfast cereals	**0.301**	0.025	**0.268**
5	Arabic pastry bread	**0.508**	0.125	**0.217**
6	Low fibre bread	0.123	**0.657**	-0.164
7	Fats	0.072	**0.533**	0.018
8	Sweet spreads	-0.098	-0.102	**0.499**
9	All fruits	**0.653**	0.024	0.072
10	Cucumber	**0.727**	-0.121	-0.143
11	Salad vegetables	**0.579**	-0.177	-0.066
12	Other vegetables	**0.746**	-0.135	-0.113
13	Soup	**0.604**	0.131	-0.113
14	Vegetable curry	**0.448**	0.160	0.146
15	Mixed Arabic dish	**0.362**	0.752	**0.296**
16	Starch	**-0.234**	-0.066	0.096
17	Fried rice	**0.673**	0.195	0.160
18	Poultry, fish	0.066	**0.464**	-0.231
19	Fried fish, poultry	-0.047	0.103	**0.243**
20	Red meat	0.079	**0.825**	0.066
21	Processed foods	0.009	**0.448**	-0.135
22	Fried potato	-0.013	-0.090	**0.513**
23	Savoury snacks	**0.530**	0.120	**0.708**
24	Crisps	**0.303**	0.100	**0.736**
25	Confectionery	0.150	0.054	0.092
26	Biscuits	0.050	-0.070	0.025
27	Crackers/crisp bread	0.194	**0.272**	**0.749**
28	Savoury sauces	-0.036	**0.623**	0.192
29	Sweetened drinks	-0.181	**0.349**	0.004
30	*Chai karak*	**0.490**	-0.103	-0.119
31	Pudding	-0.121	**0.317**	**0.329**

Using food dietary data from 59 children, Input variables are weights (g/d)
Loadings with magnitude greater than 0.2 are shown in bold.
KMO = 0.509
Bartlett's sphericity test (p<0.001)

6.10.1.2.4 Deriving an *a priori* dietary pattern: construction of the diet quality score

A diet score previously developed by Voortman et al. (2015) using national and international food-based guidelines for preschool children was used define dietary quality of children in the current study. The Diet Quality Score was developed using quantitative recommendations for preschool children from The Netherlands, Germany, Switzerland, Flanders, Northern Ireland and the US, using food-based recommendations for the general population from the age of 2 years, in addition to other scientific literature on foods that were not consistently included in these dietary guidelines (e.g. sugar-sweetened beverages, fish, and whole milk) (Voortman et al., 2015). Therefore, because of the absence of food-based dietary guidelines for preschool children in the UAE, this diet score was chosen as it was designed to represent international food based dietary guidelines.

Table 6-5 describes the ten food items included in each food group and cut-offs used to develop the diet score. In order to differentiate between more or less healthy diets in line with dietary guidelines, healthier and less healthy food items within the ten food groups were taken into account, except for the snack group and sugar-sweetened beverage food groups. Therefore, only recommended food items from the food groups were included. For instance, semi-skimmed milk, but not whole milk, was included in the dairy group; whole-grain bread, instead of white bread, was included in the bread and cereals food group.

The cut off values for the intake of foods was derived using recommendations of dietary guidelines used to develop the diet score. For each food group, using an approach previously used to develop diet scores/indices (Kennedy et al., 1995; Kleiser et al., 2009), a ratio of dietary intake was calculated. For example, a child with a vegetable intake of 80 g/d was assigned a score of 0.8 (80 divided by 100 g/d) for the vegetable component.

Each component score was truncated at 1 if a child exceeded the recommended intake for a food group, meaning that if a child exceeded the intake of fruit (>120g/d), the score given for the fruit food group was 1. For the less healthy food groups (candy and snacks and the sugar-sweetened beverages) children were given a score of 0 of intakes were equal to or above the maximum cut off, and for scores below the maximum cut off, a score proportional between 0 and 1 was assigned, as such a higher score indicates a lower intake. The scores for each component were summed together, resulting in an overall diet quality score, which ranged from 0 to 10 on a continuous scale, where higher scores represent a healthier diet that conforms to dietary recommendations.

In order to control for over or under consumption, and to reduce the potential measurement error during dietary assessment, the diet score was adjusted for energy intake (Kipnis et al., 2003). The diet score was standardised to the energy intake of each child, using the residual method (Willett, 1998).

6.10.1.2.5 Assessment of associations between dietary patterns derived using principal component analysis and diet quality scores with risk factors and BMI z-score

Linear regression was used to calculate unadjusted means of children's baseline socio-demographic, parental, cardiovascular, and behavioural risk factors, in each quintile of dietary pattern score. This was carried out for dietary patterns derived using principal component analysis and diet quality score. Trends in relationships between dietary patterns scores and BMI z-score were analysed using general linear models (GLM) with dietary pattern entered as a continuous variable. Multivariate linear models were used to assess relationships between BMI z-score and quintiles of dietary pattern score. The fully adjusted models were adjusted for age, sex, maternal BMI, maternal educational level and energy intake.

Table 6-5 Ten food groups and cut-offs used to develop diet score

Food group	Cut-off	Included items	Excluded items
Vegetables	≥ 100 g/d	Fresh, frozen or canned vegetables	Pickles
Fruit	≥ 150 g/d	Fresh fruit or canned without added sugar	Canned fruits sweetened with sugar, fruit juices
Bread and cereals	≥ 70 g/d	Whole-wheat bread, crackers, oatmeal, muesli without added sugar	White bread or crackers, breakfast cereals with added sugar
Rice, Pasta, Potatoes and Legumes	≥ 70 g/d	Boiled or steamed potatoes, whole- wheat pasta, couscous, whole-grain rice, legumes	Fried potato products (croquettes, chips), white pasta, white rice
Dairy	≥ 350 g/d	Semi-skimmed and skimmed milk, yoghurt without added sugars, unsweetened soy milk, low fat and reduced fat cheeses (<30%far in dry matter)	Milk products with added sugar, full fat cheeses, whole milk and yoghurts
Meat, eggs, and meat substitutes	≥ 35 g/d	Lean meats, eggs, tofu tempeh	Processed meats (e.g. burgers, hot dogs)
Fish	≥ 15 g/d	Fresh or canned fish, steamed, baked	Fried battered fish (e.g. fish fingers)
Oils and fats	≥ 25 g/d	Low-fat margarine (< 16g saturated fat, < 1g trans fat per 100g), vegetable oils	Butter, ghee, solid cooking or frying fats
Candy and snacks	≤ 20 g/d	Ice cream, puddings, crisps, biscuits, fruit gums, fried Arabic sweetens, cakes and chocolate	-
Sugar sweetened beverages	≤ 100 g/d	Soft drinks, fizzy drinks, *chai karak,* sweetened drinks	-

Based on the guidelines and literatures Details of foods included in each food group are described in Voortman et al., (2015)

6.10.1.2.6 Agreement between two methods used to identify dietary patterns

The correlation between dietary patterns identified using principal component analysis (see section 6.10.1.2.3) and diet quality score (see section 6.10.1.2.4) were assessed used Pearson's correlation coefficient. The agreement between tertiles of the 'traditional/health conscious' dietary pattern and diet quality score was assessed using Cohen's Kappa statistic.

PART B:

6.10.1.3 Study 3: Effectiveness of healthy lifestyle tool: randomised controlled trial findings (Chapter 9)

6.10.1.3.1 Evaluate the effectiveness of the Eat Right Emirates tool in preventing preschool overweight and obesity

The primary outcome was change in BMI z-score, which is commonly used in obesity intervention trials as an outcome measure, as it is considered to be a good measure of intervention effectiveness and can assess fat mass change over a period of time (Cole et al., 2005; Hunt et al., 2007).

An intention to treat analysis was performed. This refers to the process of analysing all randomised subjects in the groups they were allocated, irrespective of their adherence to the study protocol (e.g. compliance). It is often described as 'once randomised, always analysed' (Kruse et al., 2002). Therefore, intention-to-treat analysis avoids overly positive estimates of the effectiveness of an intervention by analysing all subjects within the groups to which they were initially randomised (Gupta, 2011).

Most outcome measures, except for skinfold thickness, were normally distributed. Therefore, data were reported as mean and standard deviation, and parametric tests to test the intervention effectiveness were used. Anthropometric, cardiovascular, behaviour, and dietary data were analysed before (at baseline) and after intervention at six months (at follow-up) and an intention to treat analysis using baseline observations. Differences between randomised groups were compared at baseline and at 6 months follow-up (end of intervention) using independent sample t-tests for continuous variables and chi-squared tests for categorical variables.

Linear regression analysis was used to examine differences between randomised groups after the 6-month intervention (follow-up), controlling for corresponding baseline variable, child's age, and sex, taking into account randomisation. This was performed to eliminate baseline difference, which could have influenced the unadjusted results. Within subject changes from baseline to 6 months after the intervention were analysed using paired t-test. Within subject change between randomised groups were compared using independent t-tests.

Chapter 7 Study 1 Results: Risk factors of preschool obesity in the United Arab Emirates

It is health that is the real wealth and not pieces of gold and silver – Mahatma Gandhi

7.1 Introduction

Multiple factors, starting from early life, have been suggested to influence a child's risk of overweight and obesity (Woo Baidal et al., 2016). However, little is known about the determinants of preschool obesity in the Arabian Gulf. As shown in the systematic review in Chapter 2 (section 2.4) , to date, no study has investigated risk factors of preschool obesity in the UAE. Hence, this study aimed to investigate associations between early life risk factors and preschool overweight and obesity in the UAE.

7.2 Results

Complete data were available for 150 preschool children. The methods and description of outcome measures have been described in Chapter 6.

7.2.1 Baseline socio-demographic, parental and anthropometric characteristics of study participants

The characteristics of the study population are summarised in Tables 7-1 to 7-5. Socio-demographic characteristics of the study population, along with the reference population data for Abu Dhabi (capital city of Al Ain), are presented in Table 7-1. Sources of national data were limited, and therefore data from large studies were also included for comparison with the current study population.

7.2.1.1 Socio-demographic characteristics

Of the children included, 57% were boys (85/150), and the mean (SD) age of children was 4.4 (0.6) years. The sex ratio is consistent with the national data from the latest report in 2005 by the Statistics Centre Abu Dhabi (SCAD), in which the proportion of males and females was 51% vs. 49% (National Bureau of Statistics, 2011) for Emirati nationals. Most of the study population were Emirati nationals (144/150, 96%), followed by Palestinians (3/150, 2%), Syrians (2/150, 1.3%) and one Jordanian (1/150, 0.7%). This was expected, because the preschool was chosen for its high proportion of Emirati children. National data from Abu Dhabi, on the other hand, reports that non-Emirati nationals are the majority population, and only 29% are Emirati nationals (National Bureau of Statistics, 2011). Although the current study population is an over-representation of Emirati population, the ratio of Emiratis to non-Emiratis is comparable to a recent study in carried out in 91 kindergartens in Ras Al Khaimah (UAE), where over 90% of students were Emirati citizens (AlBlooshi et al., 2016) (Table 7-1).

Almost all mothers in the study population were married (145/150, 97%), which is greater than the national population of Abu Dhabi, where 37% were married (National Bureau of Statistics, 2011). Most of the study population were highly educated, with 56% of mothers achieving tertiary level education (university degree) (82/150). This is in contrast to national data, where 23% of Emirati men and women combined were reported to attain a tertiary level education. However, the current population is similar to a large study of 3,820 Emirati citizens by Ng et al. (2011), who reported that 34% of mothers had a university degree, and 52% were married (Table 7-1).

The mean (SD) age of mothers was 32.9 (4.8) years and for fathers it was 37.0 (6.7) years. Mean (SD) BMI was 27.6 (5.9) kg/m^2 for mothers and 28.5 (5.0) kg/m^2 for fathers (Table 7-1). These findings are consistent with findings from Ng et al. (2011) study, which reported that the mean BMI of women >19years was 28.8 (0.8) kg/m^2.

The social class of the study population was determined by the father's occupation. Most fathers were in non-manual occupations (141/146, 97%), consistent with the National Bureau of Statistics data in Abu Dhabi (7% of the whole population were in manual occupations) (Table 7-1). However, national data represent the whole population of Abu Dhabi, which may vary from people living in the Al Ain district.

National data from the Demographic, Social and Health indicators for Countries of the Eastern Mediterranean (World Health Organisation, 2013a) indicate that 19% of men in the UAE in 2013 were smokers, which is slightly lower than the prevalence of smoking in the current study (25% v 19%). Smoking among women in the UAE is an uncommon practice, and national data indicate that only 2% of Emirati women smoke. This is comparable to findings in the current study population, which found that no women in the current study smoked (or reported smoking in the past) (Table 7-1). However, because of the social stigma accompanying smoking the Middle Eastern region, many women may intentionally misreport data related to smoking.

The mean (SD) birth weight of children was 2.9 kg (0.5), and 15% of children were born with a high birth weight (>4 kg), while 1% of children were born with a low birth weight (<2.5kg), which is consistent with national data for 2010, when 3% of children were born with a low birth weight (Table 7-1). Although national data on parity and birth weight is scarce, parity and mean birth weight of the study population were consistent with a large study by Gardner et al. (2015) in the UAE.

Eleven percent (17/150) of children were classified as overweight/obese, and 89% were classified as not overweight/obese (133/150). No gender differences were found (Table 7-2). Overweight/obesity rates were closely comparable to the prevalence reported in a recent large study by AlBlooshi et al. (2016) (n=6,731), where 11.2% of children aged between 3 and 6 years were overweight and obese (BMI for age >95th percentile).

Overall, both girls and boys were closely matched for socio-demographic, parental and anthropometric characteristics (Tables 7-1 to 7-5). No differences were found between girls and boys for anthropometric measures, except sum of skinfold thickness, which was significantly higher for girls compared to boys (p<0.0001)(Table 7-2).

7.2.2 Baseline infant feeding practices

In the study population, 3% of children (4/150) were never breastfed, 43% were breastfed for less than six months (65/150), and 19% of children were breastfed for more than 18 months (28/150) (Tables 7-3 and 7-4). The mean duration of any breastfeeding was 11 months. Twenty seven percent of children were never exclusively breastfed (40/150), while 56% of children were exclusively breastfed between 3 and 6 months. The mean duration of exclusive breastfeeding was 3.0 months (Table 7-3). The average age of complementary feeding was 4.9 months, and 91% of children were introduced to solids after 4 months (136/150) (Table 7-4).

No significant difference was found between girls and boys in relation to infant feeding practices, except for age of complementary feeding, where 5% of boys and 15% of girls were introduced to complementary foods before 4 months; p=0.03 (Table 7-4).

7.2.3 Baseline behavioural characteristics: physical activity, sedentary behaviour and sleep duration

On average, physical activity per week was 11.1 hours (SD 5.6 hours), and 21% of children engaged in more than three hours of physical activity per day, as recommended for preschool children in the UK (National Institute for Health and Care Excellence, 2006). The mean time spent in sedentary activity (watching TV/video games) per week was 12.4 hours (SD 8.1 hours) and 91% spent more than one hour per day in sedentary activities (Table 7-5).

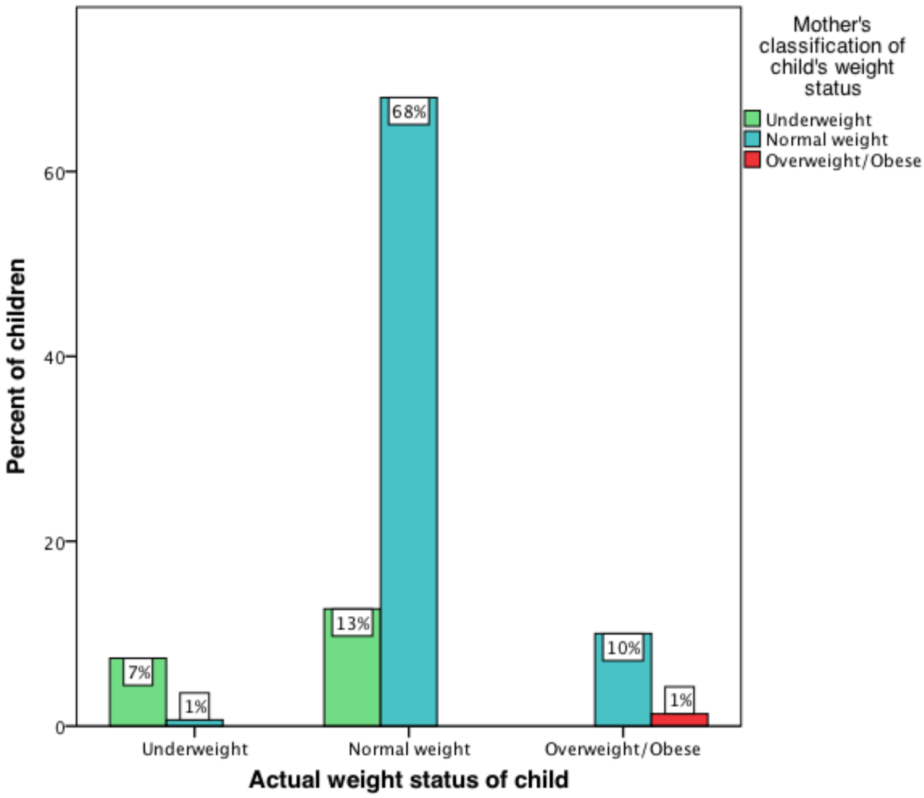
The average night-time sleep duration in the study population was 9.4 hours per night (SD 1.9 hours). Short sleep duration, defined by Chen et al. (2008), as less than 11 hours per night for children under the age of 5, was reported in 95% of the sample (Table 7-5).

7.3 Mothers' perception of child's weight status

Mothers were asked to classify their child's weight as 'underweight', 'normal', 'overweight and obese'. 79% of mothers perceived their child's weight as normal (118/150), and only 1% (2/150) perceived their child to be overweight or obese (Figure 7-1). 24% of the mothers misclassified their child's weight status, while 76% correctly classified their child's weight status**.** Most (68%) of the mothers accurately classified their child's weight as normal, 10% wrongly classified their overweight/obese children as normal weight, and 13% classified their normal weight children as underweight.

There was a fair agreement between the mother's perception and the actual measurement of each child's of weight status (Cohen's Kappa = 0.33; p<0.001).

Figure 7-1 Mother's perception of child's weight status



7.4 Risk factors of preschool overweight/obesity

Univariate and multivariate linear regression models examining associations between potential risk factors and BMI z-score are presented in Tables 7-6 to 7-8. Univariate and multivariate logistic regression models examining associations between risk factors and weight status (overweight/obese v not overweight/obese) are presented in Tables 7-9 to 7-12.

Regression models were adjusted for confounders known to influence overweight/obesity (age, sex, mother's BMI, mother's age, maternal education level, father's BMI and social class).

7.4.1 Socio-demographic and parental factors

Only maternal age was significantly associated with lower BMI z-score in the univariate model (β= -0.04; 95% CI: -0.08 to -0.002; p=0.04)**,** which remained borderline significant (p=0.05) following the adjustment for confounders (age, sex, mother BMI, maternal education level, father BMI and social class) (Table 7-6).

7.4.2 Birth weight

Birth weight was found to be positively associated with preschool BMI z-score in the unadjusted model (β= 0.40; 95% CI: 0.51 to 0.75; p =0.03). However, this association was no longer significant after adjustment for confounders (p=0.09) (Table 7-7).

Twenty four percent (4/17) of overweight/obese children had a birth weight >4kg, while 71% (12/17) of them had a birth weight in the normal range (>2.5 to 3.9kg; p=0.01) (Table 7-10). However, no statistical difference was found between groups using chi-squared tests.

7.4.3 Infant feeding practices

7.4.3.1 Association with BMI z-score

Duration of any breastfeeding (months) was significantly associated with a lower BMI z-score in the unadjusted model (β= -0.03; 95% CI: -0.05 to -0.01; p= 0.01). This effect was attenuated after adjustment for confounders (age, sex, mother BMI, mother age, maternal education level, father BMI and social class). Each month increase in the duration of any breastfeeding was associated with -0.02 lower BMI z-score (95% CI: -0.05 to 0.00; p=0.05)(Table 7-7). This association remained unchanged following the addition of birth weight to the model (β=-0.02; 95% CI: -0.05 to 0.00; p=0.05).

A later age of complementary feeding was associated with a lower BMI z-score, with a -0.43 lower BMI z-score per month (95% CI -0.60 to -0.027; p<0.001). The association remained after adjustment for confounders. Each month increase in the age of complementary feeding was associated with a -0.39 lower BMI z-score (95% CI -0.57 to 0.21; p<0.001)(Table 7-7).

This association also remained significant after further adjustment for the same confounding factors and additionally birth weight (β= -0.38; 95% CI: -0.57 to -0.19; p<0.001). Table 7-8 presents linear regression analyses between infant feeding practices and BMI z-score according to gender. Following adjustment for confounders, only gender differences for the regression analysis for age of complementary feeding and BMI z-score were found. However, no significant interactions between gender x age of complementary feeding on BMI z-score were identified.

No associations were found between the duration of exclusive breastfeeding (p=0.2) or duration of formula feeding (p=0.7) and BMI z-score, in either unadjusted or adjusted models (Table 7-7).

7.4.3.2 Association with overweight/obesity

Associations between infant feeding practices and overweight/obesity risk were examined using logistic regression analysis. Unadjusted and adjusted regression models are presented in Tables 7-10 and 7-11.

In unadjusted models, the risk of overweight/obesity was significantly lower among children who were exclusively breastfed for 3 to 6 months compared to those who were never exclusively breastfed (OR=0.15, 95% CI: 0.04 to 0.59; p=0.01) (Table 7-10). Following adjustment for confounders (age, sex, mother's BMI, mother's age, maternal education level, father's BMI and social class), the association remained significant (90% lower risk 95% CI: 0.02 to 0.54; p=0.01). The duration of exclusive breastfeeding was also found to be associated with a lower risk of overweight/obesity in the unadjusted model (OR= 0.63, 95% CI: 0.48 to 0.84; p<0.001). After adjustment for confounding factors, each month of exclusive breastfeeding was associated with a 41% lower risk of overweight and obesity (95% CI: 0.42 to 0.84; p=0.003).

In relation to the duration of any breastfeeding, in the unadjusted model, each month increase in any breastfeeding lowered the risk of being overweight/obese by 27% (95% CI: 0.60 to 0.89; p<0.001). After adjustment for confounding factors, this association remained significant (OR=0.74, 95% CI: 0.61 to 0.91; p=0.01) (Table 7-10).

The risk of overweight/obesity was significantly lower among those who were *ever* breastfed for more than six months, compared to those who were *never* breastfed (OR=0.03, 95% CI: 0.00 to 0.76; p=0.03) in the unadjusted model. However, this association was no longer significant after adjusting for confounders (p=0.06) (Table 7-11). Later introduction of complementary foods was associated with a lower risk of being overweight/obese by 89% (95% CI: 0.04 to 0.29; p<0.001) in the unadjusted model, and this was little changed after adjustment for confounding factors (86% lower risk 95% CI: 0.05 to 0.39; p<0.001) (Table 7-11).

Also, late (>4 months) compared with early (<4 months) introduction of complementary feeding was associated with a strong protective effect against later overweight/obesity in the fully adjusted model (OR= 0.03; 95% CI: 0.00 to 0.15; p<0.001) (Table 7-11).

7.4.4 Behavioural factors

No associations were found between physical activity, sedentary behaviour, and sleep duration with BMI z-score (Table 7-6) or overweight/obesity (Table 7-12) in both univariate and multivariate linear regression models.

7.5 Summary of findings

The study population, as expected, was not representative of the Emirati population, as socio-demographic and parental characteristics differed in comparison to national data. The study population was more educated compared to the national level. However, social class in the current population was consistent with the national data. Also a higher proportion of children were Emirati nationals (97%) compared with national demographic data. However, this was expected, as this population was chosen because of the higher proportion of Emirati nationals in Al Ain compared to other cosmopolitan regions in the UAE.

In summary, this study found associations between mother's age, birth weight, and strong associations between duration of breastfeeding, age of complementary feeding with BMI z-score, and exclusive breastfeeding duration with overweight/obesity risk in children aged between 2 and 6 years. These findings are discussed fully in Chapter 10 (see section 10.2).

Figure 7-2 Duration of breastfeeding according to weight status

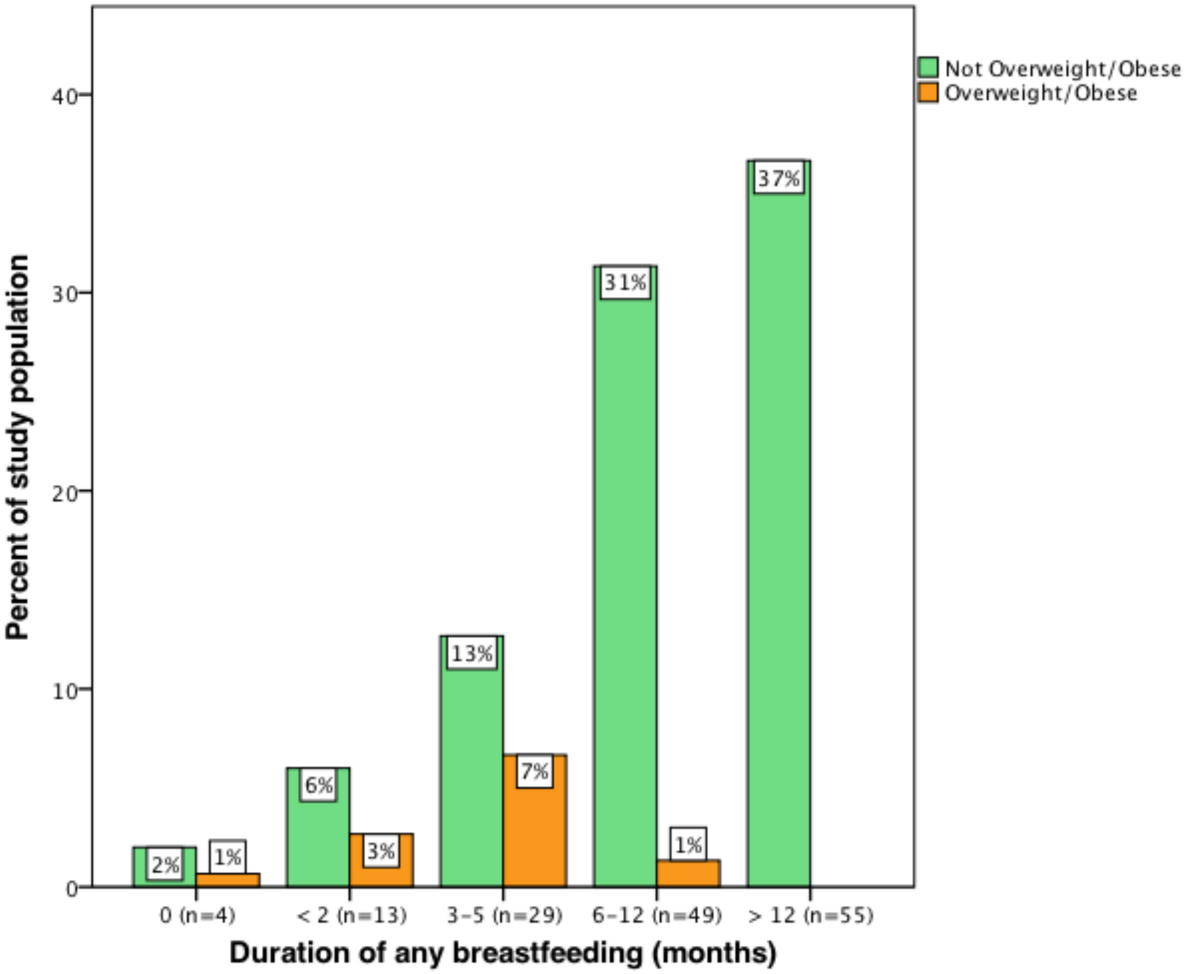


Table 7-1 Socio-demographic, parental and birth characteristics

	All n=150		Girls n=65		Boys n=85		p[1]	Comparison data National/Published	
Age, years	4.4	(0.8)	4.4	(0.8)	4.4	(0.8)	0.8	-	
Mother									
Education: with degree, n (%) [2, 3]	82	(56)	32	(49)	50	(59)	0.2	23 % [4]	34 % [5]
Ethnicity: Emirati nationals, n (%) [2]	144	(96)	64	(99)	80	(94)	0.2	31 % [4]	90 % [6]
Marital status: married, n (%) [2]	145	(97)	63	(97)	82	(97)	0.9	37 % [4]	52 % [6]
Mother age, y [3]	32.9	(4.8)	32.6	(4.9)	33.1	(4.8)	0.5	-	
Mother BMI, kg/m^2 [3]	27.6	(5.0)	27.8	(5.4)	27.4	(4.6)	0.6	-	28.8(0.8) [6]
Domestic-helper, n (%) [2]	145	(97)	65	(100)	80	(94)	0.1	-	
Paternal									
Social class: Manual, n (%) [2, 3]	5	(3)	1	(2)	4	(5)	0.4	7 % [4]	-
Father age, y [7]	37.0	(6.7)	36.1	(5.7)	37.6	(7.4)	0.2	-	-
Father BMI, kg/m^2 [7]	28.5	(5.0)	28.3	(4.7)	28.8	(5.1)	0.7	-	-
Father smoking, n (%) [2, 8]	38	(25)	19	(29)	19	(22)	0.4	19 % [9]	-
Pregnancy characteristics									
Birth order[2]									
1st	40	(27)	17	(26)	23	(27)	0.9	-	-
2nd	43	(29)	18	(28)	25	(29)			
> 3rd	67	(45)	30	(46)	37	(44)			
Parity	3.7	(1.7)	3.9	(1.7)	3.7	(1.7)	0.4	-	3.4 (2.1) [10]
Birth weight, kg	2.9	(0.5)	2.8	(0.6)	3.0	(0.5)	0.2	-	3.2 (0.6) [10]
Birth weight, kg[2]							0.1		
<2.5, n (%)	1	(1)	1	(2)	0			3 % [9]	-
2.5 - 3.9, n (%)	129	(84)	50	(77)	76	(89)		-	-
>4.0, n (%)	23	(15)	14	(22)	9	(11)		-	-

All data mean (SD) unless indicated. Significance $p<0.05$, [1] Comparison between groups using independent t-test, except [2] comparison between dichotomous variables using chi-squared test; [3] < 3% missing data; [4] National Bureau of Statistics, UAE (Abu Dhabi) combined male and female; [5] Data from Al Blooshi et al. (2016); [6] Data from Ng et al, (2011); [7] <15% missing data; [8] smoking was only reported by fathers, no mothers smoked; [9] WHO/EMRO (2013); [10] Data from Gardner et al., 2015.

Table 7-2 Anthropometric, body composition and cardiovascular characteristics

	All n=150		Girls n=65		Boys n=85		p
Anthropometry							
Height, cm[1]	104.9	(6.9)	103.8	(7.0)	105.7	(6.7)	0.1
Height z-score[1]	-0.1	(1.0)	-0.3	(1.0)	0.01	(1.0)	0.1
Weight, kg[1]	17.1	(3.2)	17.1	(3.6)	17.2	(2.8)	0.8
Weight z-score[1]	-0.06	(1.2)	-0.1	(1.3)	-0.05	(1.1)	0.9
Waist circumference, cm[1]	52.9	(4.5)	53.7	(5.7)	52.4	(3.3)	0.1
Hip circumference, cm[1]	59.5	(4.9)	60.0	(5.7)	59.0	(4.2)	0.2
BMI, kg/m^2 [1]	15.5	(1.7)	15.7	(2.0)	15.3	(1.3)	0.1
BMI z-score[1]	0.01	(1.1)	0.2	(1.3)	-0.1	(1.0)	0.2
Weight status[2]							
Not overweight/obese, n (%)	133	(89)	55	(85)	87	(92)	0.2
Overweight/Obese, n (%)	17	(11)	10	(15)	7	(8)	
Body composition							
Sum of skinfold thickness, mm[3, 4]	29.1	(1.3)	32.1	(1.3)	26.9	(1.2)	**<0.001**
Cardiovascular							
Systolic blood pressure, mmHg[4]	96.5	(7.4)	97.0	(7.5)	96.1	(7.3)	0.5
Diastolic blood pressure, mmHg[4]	58.0	(6.7)	57.8	(6.5)	96.1	(7.3)	0.7
Heart rate, beats/min[4]	103.0	(11.1)	104.0	(10.0)	102.2	(11.8)	0.4

All data mean (SD) unless indicated; significance p<0.05
[1] Comparison between groups using independent t-test,
[2] Comparison between dichotomous variables using chi-squared test
[3] Log_e transformed, geometric mean (coefficient of variation)
[4] <3% missing data

Table 7-3 Characteristics of birth weight and Infant feeding practices

	All n=150	Girls n=65	Boys n=85	p
Birth weight, kg[1]	2.9 (0.5)	2.8 (0.6)	3.0 (0.5)	0.2
Birth weight, kg [2]				0.1
<2.5, n (%)	1 (1)	1 (2)	0	
2.5 - 3.9, n (%)	129 (84)	50 (77)	76 (89)	
>4.0, n (%)	23 (15)	14 (22)	9 (11)	
Duration Exclusive breastfeeding, months[1]	3.0 (2.3)	3.2 (2.2)	2.9 (2.4)	0.5
Exclusive breastfeeding[2]				0.5
Never, n (%)	40 (27)	15 (23)	25 (29)	
<2 months, n (%)	26 (17)	10 (15)	16 (19)	
3 – 6 months, n (%)	84 (56)	40 (62)	44 (52)	
Exclusive breast feeding[2]				1.0
< 4 months, n (%)	76 (51)	33 (51)	43 (48)	
> 4 months, n (%)	74 (49)	32 (49)	42 (49)	
Exclusive breast feeding[2]				1.0
< 6 months, n (%)	116 (77)	50 (77)	66 (78)	
> 6 months, n (%)	34 (23)	15 (23)	19 (22)	
Duration of any breastfeeding, months[1]	11.0 (8.0)	10.6 (8.3)	11.2 (7.8)	0.6
Duration of any breastfeeding[2]				0.8
Never breastfed, n (%)	4 (3)	2 (3)	2 (2)	
Ever breastfed, n (%)	146 (97)	63 (97)	83 (98)	
Duration of any breastfeeding[2]				
Never breastfed, n (%)	4 (3)	2 (3)	2 (2)	0.6
< 6 months, n (%)	65 (43)	31 (48)	34 (40)	
> 6 months, n (%)	81 (54)	32 (49)	49 (58)	

All data mean (SD) unless indicated; significance $p<0.05$

[1] Comparison between groups using independent t-test

[2] Comparison between dichotomous variables using chi-squared test

Table 7-4 Characteristics of infant feeding practices

	All n=150		Girls n=65		Boys n=85		p
Duration of any breastfeeding[2]							0.7
Never breastfed, n (%)	4	(3)	2	(3)	2	(2)	
< 2 months, n (%)	13	(9)	7	(11)	6	(7)	
> 3 – 5 months, n (%)	29	(19)	14	(22)	15	(18)	
> 6 months, n (%)	104	(69)	42	(65)	62	(73)	
Duration of formula feeding, months[1]	23.5	(13.0)	22.7	(13.3)	24.1	(12.6)	0.5
Age of complementary feeding, month[1]	4.9	(1.0)	4.8	(1.1)	5.0	(1.0)	0.1
Complementary feeding[2]							
< 4 months, n (%)	14	(9)	10	(15)	4	(5)	**0.03**
> 4 months, n (%)	136	(91)	55	(85)	81	(95)	
Complementary feeding[2]							
< 6 months, n (%)	97	(65)	43	(66)	54	(64)	0.9
> 6 months, n (%)	53	(35)	22	(34)	31	(37)	

All data mean (SD) unless indicated; significance p<0.05
[1] Comparison between groups using independent t-test,
[2] Comparison between dichotomous variables using chi-squared test

Table 7-5 Child behavioural characteristics

	All n=150		Girls n=65		Boys n=85		p
Physical activity, hrs/week[1]	11.1	(5.6)	11.4	(5.6)	10.8	(5.6)	0.5
Physical activity[2]							
< 3 hrs/day, n (%)	129	(86)	56	(86)	73	(86)	1.0
> 3 hrs/day, n (%)	21	(14)	9	(14)	12	(14)	
Sedentary behaviour, hrs/week[1]	12.4	(8.1)	11.4	(7.0)	13.1	(8.7)	0.2
Sedentary behaviour[2]							
<1 hr/day, n (%)	59	(39)	28	(43)	31	(36)	0.4
>1 hr/day, n (%)	91	(61)	37	(57)	54	(64)	
Sleep duration, hrs/day[1]	9.4	(1.2)	9.6	(1.3)	9.5	(1.6)	0.8
Sleep duration, hrs/day[2]							
< 11hrs/day, n (%)	142	(95)	61	(94)	81	(81)	0.7
> 11 hrs/day, n (%)	8	(5)	4	(6)	4	(5)	

All data mean (SD) unless indicated; significance p<0.05

[1] Comparison between groups using independent t-test,

[2] Comparison between dichotomous variables using chi-squared test

Table 7-6 Association of socio-demographic, parental and behavioural factors with BMI z-score

	Unadjusted[1]			Adjusted[2]		
	β	(95% CI)	p	β	(95% CI)	p
Age, years[3]	-0.11	(-0.33, 0.12)	0.3	0.03	(-0.21, 0.27)	0.8
Gender: Male[3]	0.27	(-0.10, 0.64)	0.2	0.30	(-0.09, 0.70)	0.1
Maternal						
Mother's age, years[3]	-0.04	(-0.08, -0.002)	**0.04**	-0.04	(-0.09, 0.00)	**0.05**
Mother's BMI, kg/m^2 [3]	0.03	(-0.01, 0.06)	0.2	0.03	(-0.01, 0.07)	0.1
Educational level: with degree, n (%)[3]	0.32	(-0.05, 0.69)	0.1	0.34	(-0.06, 0.75)	0.1
Parity	-0.09	(-0.20, 0.02)	0.1	-0.07	(-0.23, 0.09)	0.4
Ethnicity: Emirati, n (%)[3]	0.20	(-0.74, 1.14)	0.4	0.21	(-0.81, 1.23)	0.7
Marital status: Married, n (%)[3]	-0.72	(-1.74, 0.30)	0.2	0.61	(-1.59, 2.83)	0.5
Paternal						
Father's age, years	-0.01	(-0.04, 0.01)	0.3	0.01	(-0.03, 0.05)	0.7
Father's BMI, kg/m^2 [3]	0.04	(-0.00, 0.08)	0.1	0.03	(-0.01, 0.07)	0.2
Social class: non manual, n (%)[3]	0.94	(-0.07, 1.94)	0.1	0.74	(-0.26, 1.75)	0.1
Behaviour						
Physical activity, hrs/week	0.02	(-0.01, 0.05)	0.2	0.03	(-0.01, 0.06)	0.1
Sedentary behaviour, hrs/week	-0.00	(-0.03, 0.02)	0.8	0.01	(-0.02, 0.03)	0.5
Sleep duration, hrs/d	0.09	(-0.04, 0.21)	0.2	0.06	(-0.08, 0.19)	0.4

[1] Linear regression analyses; significance $p<0.05$
[2] Multivariate linear regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI.
[3] Variable excluded in corresponding adjusted model

Table 7-7 Association of birth weight and infant feeding practices with BMI z-score

	Unadjusted[1] β (95% CI)	p	Adjusted[2] β (95% CI)	p	Adjusted[3] β (95% CI)	p
Birth weight, kg	0.40 (0.05, 0.75)	**0.03**	0.34 (-0.05, 0.72)	0.1	-	-
Duration of exclusive breastfeeding, months	-0.06 (-0.14, 0.02)	0.2	-0.05 (-0.14, 0.03)	0.2	-0.05 (-0.14, 0.03)	0.2
Exclusive breastfeeding						
< 4 months[4]	1.00 (ref)	0.1	1.00 (ref)	0.3	1.00 (ref)	0.3
> 4 months	-0.32 (-0.68, 0.05)		-0.22 (-0.61, 0.17)		-0.22 (-0.61, 0.17)	
Duration of any breastfeeding, months	-0.03 (-0.05, -0.01)	**0.01**	-0.02 (-0.05, 0.00)	**0.05**	-0.024 (-0.05, 0.00)	**0.05**
Breastfeeding						
Never breastfed[4]	1.00 (ref)	0.9	1.00 (ref)	1.0	1.00 (ref)	1.0
Ever breastfed	-0.09 (-1.23, 1.06)		-0.02 (-1.14, 1.09)		0.01 (-1.09, 1.12)	
Duration of any formula feeding, months	-0.003 (-0.02, 0.01)	0.7	-0.00 (-0.02, 0.01)	0.7	-0.01 (-0.02, 0.01)	0.5
Age of complementary feeding, months	-0.43 (-0.60, -0.27)	**<0.001**	-0.39 (-0.57, -0.21)	<**0.001**	-0.38 (-0.57, -0.19)	**<0.001**
Age of complementary feeding						
< 4 Months[4]	1.00 (ref)	**<0.001**	1.00 (ref)	**<0.001**	1.00 (ref)	**<0.001**
> 4 months	-1.84 (-2.40, -1.29)		-1.48 (-2.14, -0.83)		-1.46 (-2.12, -0.79)	

[1] Univariate linear regression analyses, significance p<0.05
[2] Multivariate linear regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother’s age, Social class, Father’s BMI
[3] Multivariate linear regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother’s age, Social class, Father’s BMI, Birth weight
[4] Comparison against reference group in analyses

Table 7-8 Association of infant feeding practices with BMI z-score

		Unadjusted[1]		Adjusted[2]	
		β (95% CI)	p	β (95% CI)	p
Duration of exclusive breastfeeding, months	Boys	-0.02 (-0.11, 0.07)	0.7	-0.02 (-0.12, 0.08)	0.7
	Girls	-0.12 (-0.26, 0.02)	0.1	-0.09 (-0.25, 0.07)	0.3
Duration of any breastfeeding, months	Boys	-0.04 (-0.06, -0.01)	**0.01**	-0.03 (-0.06, 0.00)	0.1
	Girls	-0.02 (-0.06, 0.02)	0.3	-0.01 (-0.06, 0.03)	0.5
Duration of any formula feeding, months	Boys	0.004 (-0.01, 0.02)	0.7	-0.003 (-0.02, 0.02)	0.8
	Girls	-0.10 (-0.03, 0.02)	0.4	-0.01 (-0.04, 0.02)	0.5
Age of complementary feeding, months	Boys	-0.30 (-0.52, -0.09)	**0.01**	-0.30 (-0.53, -0.07)	**0.01**
	Girls	-0.54 (-0.80, -0.28)	**<0.001**	-0.42 (-0.74, -0.11)	**0.01**

[1] Univariate linear regression analyses
[2] Multivariate linear regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI
Significance $p<0.05$

Table 7-9 Association of socio-demographic factors and parental characteristics with overweight/obesity

	Not OWT/OB (n=133)	OWT/OB (n=17)	p	Unadjusted[3] OR (95% CI)	p	Adjusted[4] OR (95% CI)	p
Age, years[1,5]	3.9 (0.8)	4.1 (0.9)	0.4	1.07 (0.57, 2.00)	0.8	1.43 (0.69, 2.98)	0.3
Gender: Male, n (%)[2, 5]	78 (59)	7 (41)	0.2	2.02 (0.73, 5.65)	0.2	1.74 (0.52, 5.74)	0.4
Maternal							
Marital status: Married, n (%)[2, 5]	130 (98)	15 (88)	0.1	0.17 (0.03, 1.12)	0.1	-	-
Ethnicity: UAE, n (%)[2, 5]	127 (96)	17 (100)	1.0	-	-	-	-
Parity[1]	3.8 (1.7)	3.4 (1.3)	0.3	0.83 (0.60, 1.16)	0.3	0.99 (0.61, 1.59)	1.0
Mother's age, y [1]	33.1 (4.8)	31.1 (4.2)	0.1	0.91 (0.81, 1.02)	0.1	0.95 (0.83, 1.09)	0.4
Mother's BMI, kg/m^2 [1]	27.5 (5.1)	28.1 (3.3)	0.6	1.02 (0.93, 1.13)	0.6	1.02 (0.91, 1.14)	0.7
Education: with degree, n (%)[2, 5]	72 (54)	10 (58)	0.8	1.19 (0.42, 3.32)	0.7	0.94 (0.28, 3.22)	0.7
Paternal							
Father's age, y[1]	37.0 (6.4)	36.2 (9.1)	0.6	0.98 (0.89, 1.07)	0.6	1.03 (0.93, 1.15)	0.5
Father's BMI, kg/m^2 [1]	28.4 (4.9)	30.3 (4.8)	0.2	1.07 (0.97, 1.18)	0.2	1.07 (1.07, 0.96)	0.2
Social class: Non-manual, n (%)[2, 5]	126 (95)	15 (100)	1.0	-	-	-	-
Father smoking, n (%)[2]	35 (26)	3 (18)	0.4	0.60 (0.16, 2.21)	0.4	0.82 (0.19, 3.48)	0.7

All data mean (SD) unless indicated; OWT/OB, overweight/obese; OR, odds ratio; CI, confidence interval significance $p<0.05$

[1] Comparison between groups using independent t-test

[2] Comparison between dichotomous groups using chi-squared test

[3] Univariate logistic regression analyses

[4] Multivariate logistic regression adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI.[5] Variable excluded in corresponding adjusted model.

[5] Comparison against reference group in analyses.

Table 7-10 Association of birth weight and infant feeding practices with overweight/obesity

	Not OWT/OB (n=133)	OWT/OB (n=17)	p	Unadjusted[3] OR (95% CI)	p	Adjusted[4] OR (95% CI)	p
Birth weight, kg[1]	2.8 (0.5)	3.0 (0.7)	0.3	1.76 (0.62, 4.99)	0.3	1.79 (0.50, 6.39)	0.4
Birth weight, kg							
<2.5, n (%)[2]	0	1 (6)	0.1	-	-	-	-
2.5 - 3.9, n (%)[2]	114 (86)	12 (71)		-	-	-	-
>4.0, n (%)[2]	19 (14)	4 (24)		-	-	-	-
Duration Exclusive breastfeeding, months[1]	3.3 (2.3)	1.2 (1.2)	**<0.001**	0.63 (0.48, 0.84)	**<0.001**	0.59 (0.42, 0.84)	**0.003**
Exclusive breastfeeding[2]							
Never, n (%)[5]	32 (24)	8 (47)	**0.003**	1.00 (ref)		1.00 (ref)	
< 2 months, n (%)	20 (15)	6 (35)		1.20 (0.36, 4.00)	0.8	1.26 (0.29, 5.47)	0.8
3–6 months, n (%)	81 (61)	3 (18)		0.15 (0.04, 0.59)	**0.01**	0.10 (0.02, 0.54)	**0.01**
Exclusive breast feeding[2]							
< 4 months, n (%)	59 (44)	17 (100)	**<0.001**	-	-	-	-
> 4 months, n (%)	74 (56)	0		-	-	-	-
Exclusive breast feeding[2]							
< 6 months, n (%)	99 (74)	17 (100)	**0.02**	-	-	-	-
> 6 months, n (%)	34 (26)	0		-	-	-	-
Duration of any breastfeeding, months[1]	11.9 (8.0)	3.6 (2.6)	**<0.001**	0.73 (0.60, 0.89)	**<0.001**	0.74 (0.61, 0.91)	**0.01**
Duration of any breastfeeding[2]							
Never breastfed, n (%)[5]	3 (2)	1 (6)	0.4	1.00 (ref)		1.00 (ref)	
Ever breastfed, n (%)	130 (98)	16 (94)		0.37 (0.04, 3.77)	0.4	0.44 (0.04, 5.26)	0.5

All data mean (SD) unless indicated; OWT/OB, overweight/obese; OR, odds ratio; CI, confidence interval; significance $p<0.05$

[1] Comparison between groups using independent t-test, [2] Comparison between dichotomous groups using chi-squared test

[3] Univariate logistic regression analyses, unadjusted for confounders. [4] Multivariate logistic regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI. [5] Comparison against reference group in analyses.

Table 7-11 Association of infant feeding practices with overweight/obesity

	Not OWT/OB (n=133)	OWT/OB (n=17)	p	Unadjusted [3] OR (95% CI)	p	Adjusted [4] OR (95% CI)	p
Duration of any breastfeeding[2]			**<0.001**				
Never breastfed, n (%)[5]	3 (2)	1 (6)		1.00 (ref)		1.00 (ref)	
< 6 months, n (%)	50 (38)	15 (88)		0.90 (0.09, 9.30)	0.9	1.11 (0.09, 13.4)	0.9
> 6 months, n (%)	80 (60)	1 (6)		0.03 (0.00, 0.76)	**0.03**	0.05 (0.00, 1.07)	0.06
Duration of breastfeeding							
Never breastfed, n (%)[5]	3 (2)	1 (6)	**<0.001**	1.00 (ref)		1.00 (ref)	
< 2 months, n (%)	9 (7)	4 (24)		1.33 (0.10, 17.10)	0.8	1.42 (0.09, 22.19)	0.8
3–5 months, n (%)	19 (14)	10 (59)		1.58 (0.15, 17.22)	0.7	2.15 (0.16, 29.27)	0.6
> 6 months, n (%)	102 (77)	2 (12)		0.06 (0.00, 0.84)	**0.04**	0.03 (0.00, 0.83)	**0.04**
Duration Formula feeding, months[1]	22.7 (13.2)	29.7 (8.8)	**0.04**	1.05 (1.00, 1.10)	**0.04**	1.07 (1.01, 1.13)	**0.03**
Age of solid introduction, month[1]	5.1 (0.9)	3.5 (0.8)	**<0.001**	0.11 (0.04, 0.29)	<0.001	0.14 (0.05, 0.39)	**<0.001**
Complementary feeding[2]							
<4 months, n (%)[5]	4 (3)	10 (59)	**<0.001**	1.00 (ref)		1.00 (ref)	
>4 months, n (%)	129 (97)	7 (41)		0.02 (0.01, 0.09)	**<0.001**	0.03 (0.00, 0.15)	**<0.001**
Complementary feeding[2]							
< 6 months, n (%)	80 (60)	17 (100)	**<0.001**	-	-	-	-
> 6 months, n (%)	53 (40)	0		-	-	-	-

All data mean (SD) unless indicated; OWT/OB, overweight/obese; OR, odds ratio; CI, confidence interval; significance p<0.05
[1] Comparison between groups using independent t-test,
[2] Comparison between dichotomous groups using chi-squared test
[3] Univariate logistic regression analyses, unadjusted for confounders.
[4] Multivariate logistic regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI.
[5] Comparison against reference group in analyses

Table 7-12 Association of behavioural characteristics with overweight/obesity

	Not OWT/OB (n=133)		OWT/OB (n=17)		p	Unadjusted[3] OR (95% CI)	p	Adjusted[4] OR (95% CI)	p
Physical activity, hrs/week[1]	10.9	(0.3)	12.4	(5.8)	0.3	1.04 (0.96, 1.13)	0.3	1.06 (0.96, 1.17)	0.3
Physical activity[2]									
< 3 hrs/day, n (%)[5]	116	(87)	13	(77)	0.2	1.00 (ref)		1.00 (ref)	
> 3 hrs/day, n (%)	17	(13)	4	(24)		0.48 (0.14, 1.63)	0.2	0.57 (0.13, 2.48)	0.5
Sedentary behaviour, hrs/week[1]	12.4	(0.8)	12.1	(6.4)	0.9	0.99 (0.93, 1.06)	0.9	1.02 (0.95, 1.10)	0.6
Sedentary behaviour[2]					0.7				
<1 hr/day, n (%)[5]	53	(40)	6	(35)		1.00 (ref)		1.00 (ref)	
>1 hr/day, n (%)	80	(60)	11	(65)		1.22 (0.42, 3.48)	0.7	1.17 (0.35, 3.98)	0.8
Sleep duration, hrs/day[1]	9.4	(0.2)	10.0	(1.0)	0.2	1.35 (0.89, 2.05)	0.2	1.41 (0.84, 2.37)	0.2
Sleep duration, hrs/day[2]									
< 11hrs/day, n (%)[5]	126	(96)	16	(94)	0.9	1.00 (ref)		1.00 (ref)	
> 11 hrs/day, n (%)	7	(5)	1	(6)		1.13 (0.13, 9.74)	0.9	2.03 (0.18. 22.61)	0.6

All data m(SD) unless indicated; OWT/OB, overweight/obese; OR, odds ratio; CI, confidence interval; significance p<0.05
[1] Comparison between groups using independent t-test.
[2] Comparison between dichotomous groups using chi-squared test.
[3] Univariate logistic regression analyses, unadjusted for confounders.
[4] Multivariate logistic regression analyses adjusted for Age, Sex, Maternal BMI, Maternal Education level, Mother's age, Social class, Father's BMI.
[5] Comparison against reference group in analyses.

Chapter 8 Study 2 Results: Diet and preschool obesity risk in the United Arab Emirates

Everything in excess is opposed to nature – Hippocrates

8.1 Introduction

A poor diet, characterised by overconsumption of energy-dense, low nutrient foods and drinks, and a low intake of fruits and vegetables, contributes to obesity and other diet-related diseases in preschool children (Singh et al., 2008a; Butte et al., 2014). Dietary habits have been shown to track throughout childhood. This suggests that dietary exposures during the preschool years may influence longer-term dietary intake. For example, children with high energy and nutrient intake at 2 years of age are also found to have higher intakes at age 4 (Nicklas et al., 1991) (see Chapter 3).

Epidemiological studies have also found that dietary patterns established during the preschool years persist into later childhood (Mikkilä et al., 2005; Northstone and Emmett, 2008). For instance, in the ALSPAC study, three dietary patterns identified at age 3 tracked to 4, 7 and 9 years of age, with each pattern strongly correlated at each of these ages (a processed'; r=0.46, a health-conscious; r=0.41, and a traditional; r=0.35) (Northstone and Emmett, 2008). This suggests that early childhood is an important period when dietary patterns can be targeted to encourage the development of healthy eating habits and reduce the risk of disease such as obesity.

The influence of diet on preschool obesity risk in the United Arab Emirates has not been explored, as reported in the systematic review in Chapter 2. This represents a gap in the research. An understanding of dietary risk factors is needed to inform interventions that aim to prevent and manage the development of preschool obesity.

Hence, the current study aimed to: (i) describe dietary intake of preschool children in the UAE; (ii) define dietary patterns of preschool Emirati children (using two approaches, see 6.10.1.2); (iii) examine the association between energy and macronutrient intake and preschool obesity risk in the UAE; (iv) investigate associations between dietary patterns and obesity risk in preschool children in the UAE.

8.2 Results

8.2.1 Baseline subject characteristics: socio-demographic, parental, anthropometric and behavioural characteristics

Complete dietary data were available for 39% of children (59/150). Characteristics of the study population are shown in Table 8-1. There were no differences between those who did not complete the food diaries (non-completers) and completers, except there was a slight overrepresentation of older mothers in the study sample of children with complete food diaries (p=0.004). There were also more fathers in manual jobs (p=0.01) and birth weight was significantly different between the completers group compared to non-completers (p=0.03)

The mean age of children with complete dietary data was 4.4 (SD =0.8) years. Mean BMI z-score calculated using WHO 2006 growth standards and WHO 2007 references accordingly (see section 6.8.1.2) was -0.1 (SD=1.1). The majority of children (92%) of children were classified as not overweight/obese for their age and sex, with 8% classified as overweight or obese.

Dietary characteristics of the study population (n=59) are shown in Table 8-1. The average daily energy and macronutrient intake from foods and drinks according to gender is presented in Table 8-2**.** The mean daily energy intake was 1337 kcal per day. This comprised 53% from carbohydrates, 15% from protein and 32% of from fat. Children obtained, on average, 15% of their energy from saturated fat, 21% of energy from total sugars[24] and consumed on average 4.4g per day of fibre. There was no difference in energy and macronutrient intake between girls and boys (Table 8-2).

[24] Components of sugars was not investigated in this study.

8.2.2 Comparison of energy and macronutrient intake with UK Dietary Reference Values (DRVs)[25]

Table 8-3 compares the daily energy intake and nutrient intakes of children with UK DRVs. In comparison to the Estimated Average Energy Requirement (EAR) for children (see section 6.8.7.2.1, for a detailed description) (Scientific Advisory Committee on Nutrition, 2011), most (61%) of children consumed more energy than recommended, and 39% consumed less than the recommended amount of energy per day. The average daily energy intake of the study population was comparable to the level recommended by the SACN for children aged 4 years. Protein intake was two times higher than the UK Department of Health Reference Nutrient Intake (RNI) for children aged between 4 and 6 years (46g versus 19.7g, $p<0.001$) with 100% of children exceeding the RNI for protein. Fibre intake was almost three times less than is recommended (4.4g/d versus 15/g/d; $p<0.001$).

8.3 Association between energy and macronutrient intake and BMI z-score

Univariate and multivariate linear regression models were used to examine associations between dietary intake and BMI z-score. Results are presented in Table 8-4.

8.3.1 Energy intake

Total (kcal per day) and relative energy intake (per kilogram of body weight) were significantly associated with BMI z-score in the univariate analyses. Energy intake (kcal per day) was positively associated with BMI z-score ($\beta = 0.004$; 95% CI: 0.00 to 0.01; $p<0.001$). This association remained significant after adjusting for confounding factors (age, sex, mother's BMI, father's BMI, mother's age, mother's educational level, social class and physical activity) ($\beta = 0.004$; 95% CI: 0.003 to 0.01; $p<0.001$). However, although relative energy intake (kcal per

[25] Average daily energy intake was calculated as a percentage of the 2011 Scientific Advisory Committee on Nutrition (SACN) Estimated Average Requirement (EAR) for children, according to their age at dietary intake collection (SACN, 2011). Protein intake was calculated as a percentage of the Department of Health Reference Nutrient Intake (RNI) for children aged between 4 and 6 (DOH, 1991). Carbohydrate and fibre intake were compared with the SACN (2015) recommendations for children aged between two and five years old (SACN, 2015).

kilogram body weight per day) was inversely associated with BMI z-score (β = -0.004; 95% CI: 0.003 to 0.01; p<0.001), this association was lost after adjusting for confounding factors (p=0.3)(Table 8-4).

8.3.2 Carbohydrate intake

Absolute carbohydrate intake (grams per day) was found to be associated with BMI z-score, in both univariate and multivariate models. Following the adjustment for confounders one gram increase in the intake of carbohydrates was associated with a 0.02 increase in BMI z-score (95% CI: 0.01 to 0.03; p=0.01) (Table 8-4).

However, carbohydrate intake, as a percentage of energy and carbohydrate intake relative to body weight (grams per kilogram body weight per day), were inversely associated with BMI z-score in both univariate and multivariate models. In relation to carbohydrate intake as a percentage of energy, a one percent increase was associated with -0.09 lower BMI z-score after the adjustment for confounders (95% CI: -016, 0.03; p=0.004). Similarly, carbohydrate intake per kilogram body weight was associated with -0.23 lower BMI z-score (95% CI: -0.40 to -0.01; p=0.01) after adjustment for confounding factors (Table 8-4).

8.3.3 Protein intake

In the univariate model, absolute protein intake (grams per day) was positively associated with BMI z-score (β = 0.06; 95% CI: 0.03 to 0.09; p<0.001), while protein intake relative to body weight was inversely associated with BMI z-score in the unadjusted model (β = -1.06; 95% CI: -1.7 to -0.44; p<0.001). However, following the adjustment for confounders (age, sex, mother's BMI, father's BMI, mother's age, mother's educational level, social class and physical activity), the association was only significant for absolute protein intake (gram per day), where the intake of one gram of protein was associated with a 0.05 increase in BMI z-score (95% CI: 0.02 to 0.08; p=0.004). No association was found between protein intake, expressed as a percentage of energy intake, and BMI z-score (Table 8-4).

8.3.4 Fat intake

Fat intake, in grams per day and as a percentage of energy intake, were both positively associated with BMI z-score in the univariate analyses (p<0.001). After controlling for confounders, the association remained strongly significant for both absolute fat intake (grams per day) and fat intake expressed as a percentage of energy; for percentage of energy from fat, a 1% increase was associated with a 0.11 increase in BMI z-score (95% CI: 0.05 to 0.16; p=0.001). No significant association was between fat intake relative to body weight and BMI z-score (Table 8-4).

8.4 Association between energy and macronutrient intake and overweight and obesity

Dietary intake data according to weight status are presented in Table 8-5. Compared with not overweight/obese children, absolute intakes of energy (kcal per day), protein, carbohydrates and fat in grams per day were significantly greater in overweight/obese children. No differences were found for macronutrient intake either as a percentage of energy intake, or relative to body weight (Table 8-5).

In logistic regression analyses using overweight/obese as a binary outcome, a positive association was found between absolute carbohydrate, protein and fat intake (grams per day) and risk of overweight/obesity (Table 8-5) in the unadjusted model. For example, a 1 gram increase in intake of fat (grams per day) was significantly associated with a 16% increase in the risk of overweight/obesity (95% CI: 1.05 to 1.28; p=0.004). However, no associations were found between energy adjusted or relative macronutrient intake (protein, carbohydrates and fat) and overweight/obesity risk (Table 8-5).

8.4.1 Dietary patterns derived using principal component analysis

Three interpretable dietary patterns identified by principal component analysis (see, Table 6-4), explained 35.5% of the total variance in diet. High factor loadings of foods and food groups for each dietary pattern are summarised in

Box 8-1. The first dietary pattern defined by the principal component was named: 'traditional/health-conscious' and explained 16.2% of the total variance. This dietary pattern reflected a 'prudent' diet, and was characterised by high consumption of all fruits, vegetables, soups, vegetable curries, *chai karak,* mixed Arabic dishes, breakfast cereals and Arabic pastry breads. The strongest component score for this pattern was for all fruits with a factor loading of 0.72 (see, Table 6-4). The second identified dietary pattern 'processed/Western' explained 10.5%, and was characterised by high consumption of low-fibre breads, fats and oils, poultry and fish, red meats, processed foods, sweetened drinks, puddings and low consumption of milk and dairy products. The largest factor loading for this pattern was for red meats (factor loading 0.83). The third dietary pattern reflected a 'convenience/snack' diet, explaining 8.7% of the variance. This dietary pattern was characterised by a high consumption of milk, eggs, breakfast cereals, sweet spreads, fried fish and poultry, savoury snacks, crisps, and crackers. The strongest component for this dietary pattern was for crackers and crisps with factor loadings of 0.75 and 0.74, respectively.

Subject characteristics according to dietary pattern quintiles are presented in Tables 8-6 to 8-8. Children with high scores for the processed/Western pattern were more likely to be male (9/12, 75% male compared with 3/12, 25% female, p for trend = 0.04). Children with a high score for the convenience/snack pattern were more likely to have mothers with a university degree (p for trend = 0.01).

Box 8-1 Food and food groups characterising three dietary patterns identified using PCA (see Table 6.4 for factor loadings)

Dietary Pattern 1 *'traditional/health-conscious'*

Fruits, salad vegetables, other vegetables, vegetable curries, soups, breakfast cereals, mixed Arabic dishes, fried rice, *chai karak*, Arabic pastry (*chapatti*)

Dietary Pattern 2 *'processed/Western'*

Low fibre breads, fats, poultry/fish, meat products, processed foods, crackers/crisp bread, sweetened drinks and puddings

Dietary Pattern 3 *'convenience/snack'*

Milk products, eggs, breakfast cereals, Arabic pastry, sweet spreads, mixed Arabic dishes, fried fish/poultry, fried potato, crisps, crackers/crisp bread and puddings

8.4.2 Diet Quality Score

Scores calculated for each dietary component are presented in Table 8-9**.** Most children had relatively high component scores for the intake of rice, pasta and legumes (median standardised score of 0.9), and meat, eggs and poultry (median standardised score of 0.9). The scores for each single diet component were summed resulting in an overall diet score ranging from 0 to 10, where 10 denotes a healthier/high quality diet (see Chapter 6). After standardisation to an energy intake of 1200 kcal/d (see section 6.10.1.2.4), the diet score of Emirati children in the study population ranged from 1.6 to 6.1, with a mean (SD) of 3.4 (0.9) (Figure 8-1).

Subject characteristics according to dietary score quintiles are presented in Table 8-10. No differences were found between quintiles of diet score and socio-demographic, parental, anthropometric and behavioural measures.

8.5 Associations between dietary patterns, diet score and BMI z-score

One way-analysis of variance was carried out to explore relationships between quintiles of dietary patterns and BMI z-score. General linear regression models are presented in Tables 8-11 and 8-12. No associations were found between dietary patterns, diet scores and BMI z-score.

8.5.1 Correlation between *a priori* diet score and PCA-derived dietary patterns

A priori diet score had a strong positive correlation with adherence to the data-driven *a posteriori* ‘traditional/health conscious dietary pattern shown in Figure 8-2 ($r = 0.59$, $p<0.001$). No correlation was found with the other two dietary patterns derived using principal component analysis (Table 8-13).

8.5.1.1 Agreement between diet score and dietary pattern scores

The proportion of children classified in the same third of the distribution (exact agreement) and into the extreme thirds of the distribution (gross misclassification) between diet scores and dietary patterns, derived using PCA, are presented in Table 8-14.

Children in the highest third (healthiest) for both diet score and traditional/health-conscious dietary patterns (derived using PCA) were found to represent 60% of the study sample (kappa value; 0.2; $p=0.01$). This suggests that both an *a priori* derived diet score and an *a posteriori* derived dietary pattern can accurately define a healthy diet, and could be used interchangeably. No agreement was found between diet score and other dietary patterns derived using PCA.

8.6 Summary of findings

This is the first study to examine the diets of preschool children in the UAE. The primary aim of the study was to better understand the diets of preschool Emirati children, in relation to dietary intake and dietary patterns, and investigate associations with overweight/obesity and BMI z-score. Compared with the UK DRVs for children aged 4 years old, the average daily energy intake of the study population was found to comply with recommendations (Scientific Advisory Committee on Nutrition, 2011). However, protein intake was higher than the RNI of protein, and fibre intake was lower than the recommended 15 grams per day (Scientific Advisory Committee on Nutrition, 2015).

The current study derived dietary patterns using two approaches; principal component analysis (PCA) and diet quality score. Three dietary patterns were identified. A strong agreement between the traditional/health-conscious dietary pattern derived using PCA and a healthy diet quality score suggests that both methods are suitable for identifying a healthy dietary pattern in preschool children. However, no significant associations were found between dietary patterns and obesity risk.

The present study also found an inverse association between both energy adjusted and relative carbohydrate intake with BMI z-score, and a positive strong association between energy adjusted fat intake and BMI z-score, but not for relative fat intake per kilogram body weight. There were no consistent associations between protein (expressed as a percentage of energy and per kilogram body weight) and BMI z-score. Further discussion of the implications of these findings, strengths, limitations and future work is considered and discussed in Chapter 10 (section 10.3).

Table 8-1 Characteristics of the children with complete dietary data compared with the children who did not complete dietary data at baseline

	Completers (n=59)		Non-completers (n=91)		p[1]
Age, years	4.4	(0.8)	4.4	(0.9)	0.6
Sex, Male, n (%) [2]	37	(63)	48	(53)	0.2
Mother					
Ethnicity: UAE, n (%)[2]	57	(97)	87	(96)	0.8
Marital status: Married, n (%) [2]	59	(100)	86	(95)	0.1
Education: With degree, n (%) [2, 3]	36	(61)	46	(51)	0.2
Mother's age, years [3]	34.3	(4.4)	32.0	(4.9)	**0.004**
[3]Mother's BMI, kg/m^2	27.0	(4.9)	28.0	(5.0)	0.2
Father					
Social Class: Manual, n (%) [2]	5	(8)	0		**0.01**
Father's age, years [3]	37.8	(5.8)	36.4	(7.2)	0.3
[3]Father's BMI, kg/m^2	28.3	(5.0)	28.8	(4.9)	0.6
Father smoking, n (%) [2,3]	13	(22)	25	(28)	0.5
Pregnancy and Birth Characteristics					
Parity	3.9	(1.5)	3.7	(1.8)	0.6
Birth order					
1st	14	(24)	26	(29)	0.3
2nd	14	(24)	29	(31)	
3rd and more	31	(53)	36	(40)	
Birth weight, kg	3.0	(0.4)	2.8	(0.6)	**0.03**
Child Anthropometry					
Height, cm	105.0	(6.2)	104.9	(7.3)	0.9
Height z score	-0.1	(0.9)	-0.2	(1.1)	0.6
Weight, kg	17.0	(3.3)	17.2	(3.1)	0.7
Weight z score	-0.1	(1.1)	-0.1	(1.2)	0.7
Waist circumference, cm	52.8	(5.0)	53.0	(4.2)	0.8
BMI, kg/m^2	15.3	(1.7)	15.6	(1.7)	0.4
BMI z-score	-0.1	(1.1)	0.1	(1.1)	0.3
Overweight and obese, n (%)[2]	5	(8)	12	(13)	0.8
Behaviour					
Physical activity, hrs/wk	10.8	(5.9)	11.2	(5.4)	0.6
Sedentary activity, hrs/wk	12.9	(8.2)	12.0	(8.0)	0.5
Sleep duration, hrs/day	9.5	(1.3)	9.6	(1.5)	0.9

All data mean (SD), unless indicated
[1] Comparison between groups using independent t-test (continuous variables)
[2] Chi-square test for differences between dichotomous variables
[3] <4% missing data
Significance p<0.05

Table 8-2 Energy and macronutrient intake of children in the study sample according to gender

Nutrient	All (n=59)		Boys (n=37)		Girls (n=22)		p[1]
Energy							
Total energy, kcal/d	1337.2	(207.4)	1321.4	(177.8)	1363.8	(251.8)	0.5
Energy, kcal/kg/d	79.7	(10.2)	80.4	(11.6)	78.4	(7.3)	0.5
Carbohydrate							
Carbohydrate, g/d	172.2	(28.2)	170.5	(26.3)	174.9	(31.6)	0.6
Carbohydrate, %E	52.8	(4.1)	52.9	(4.0)	52.7	(4.4)	0.9
Carbohydrate, g/kg/d	10.3	(1.6)	10.4	(1.8)	10.1	(1.3)	0.5
Protein							
Protein, g/d	46.3	(8.2)	45.6	(8.2)	47.5	(8.2)	0.4
Protein, %E	15.2	(2.1)	15.1	(2.1)	15.3	(2.1)	0.7
Protein, g/kg/d	2.8	(0.4)	2.8	(0.5)	2.8	(0.4)	0.9
Fat							
Fat, g/d	56.2	(12.7)	55.4	(10.5)	57.5	(16.0)	0.6
Fat, %E	32.0	(4.2)	32.0	(4.0)	32.0	(4.7)	1.0
Fat, g/kg/d	3.3	(0.6)	3.4	(0.7)	3.3	(0.6)	0.6

All data are mean (SD), Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d per kilogram of body weight per day NSP, non-starch polysaccharides.
[1] Comparison between groups using independent t-test.
Significance $p<0.05$

Table 8-3 Energy and macronutrient intake of children compared with UK Dietary Reference Values (DRVs)

Nutrient	DRV	Mean[1] (% DRV)	SE	25th Percentile	75th Percentile	p[2]	Meeting recommendation: Above	Meeting recommendation: Below
Daily energy intake, kcal	1338 [3]	1337.2 (99.9)	27.0	1171.0	1443.1	1.0	61% [4]	39% [4]
Total carbohydrate, g/d	-	172.2	3.7	150.1	184.7	-	-	-
Total carbohydrates, %E	50 [5]	52.8 (105.6)	0.5	50.6	55.4	**<0.001**	20.3% [6]	79.7% [6]
Total sugar, g/d	-	70.4	2.1	55.9	78.2	-	-	-
Total sugar, %E	-	21.1	0.6	18.2	23.9	-	-	-
Dietary Fibre as NSP, g/d	15 [5]	4.4 (29.3)	0.2	3.0	5.7	**<0.001**	0% [6]	100% [6]
Total fat, g/d	-	56.2	1.7	48.8	59.9	-	-	-
Total fat, %E	35 [7]	32.0 (91.4)	0.5	29.1	34.3	-	-	-
Saturated Fat, %E	11[7]	14.7 (133.6)	0.3	13.1	16.1	-	-	-
Protein, g/d	19.7[8]	46.3 (235)	1.1	39.7	52.8	**<0.001**	100% [9]	0% [9]
Protein, %E	5.8 [8]	15.2	0.3	13.6	16.8	**<0.001**	100% [9]	0% [9]

SE Standard error; kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; NSP, non-starch polysaccharides

[1] Mean intake of study sample

[2] p value for difference between mean intake of children and the DRV using one sample t-test. Significance $p<0.05$

[3] DRV for energy intake is based on the Scientific Advisory Committee on Nutrition (2011) estimated average requirements (EARS) for children aged 4 years (average age of study sample: 4.4 years) and the mean of the mid-point of DRVs males (1386 kcal/d) and females (1291kcal/d) (Scientific Advisory Committee on Nutrition, 2011)

[4] Percentage above or below EAR according to age and sex.

[5] RNI for children 2-5 years of age from Scientific Advisory Committee on Nutrition (2015).

[6] Percentage above or below RNI for children 2-5 years of age from SACN (2015) 50% for carbohydrates as a percentage of energy intake, and 15g/d for dietary fibre.

[7] RNI for children aged 5 and over; not more than 35% of total fat as a percentage of energy intake and not more than 11% for saturated fat as a percentage of energy intake based on COMA 1991 recommendation.

[8] RNI for children 4-6 years of age from Department of Health, Dietary Reference Values for Food Energy and Nutrients for the United Kingdom, HMSO, 1991(Department of Health 1991), %E calculated as from RNI of protein (19.7g/d) and EAR (1338 kcal/day) (19.7*4)/1338 multiplied by 100

[9] Percentage above or below RNI for protein for children 4–6 years of age (19.7g/d).

Table 8-4 Associations between energy and macronutrient intake with BMI z-score

	Unadjusted[1]			Adjusted[2]			Adjusted[3]		
	β	**(95% CI)**	**p**	**β**	**(95% CI)**	**p**	**β**	**(95% CI)**	**p**
Energy									
Total energy, kcal/d	0.004	(0.00, 0.01)	**<0.001**	0.004	(0.003, 0.01)	**<0.001**	0.004	(0.003, 0.01)	**<0.001**
Energy, kcal/kg/d	-0.03	(-0.06, -0.00)	**0.03**	-0.02	(-0.05, 0.01)	0.1	-0.02	(-0.05, 0.02)	0.3
Carbohydrates									
Carbohydrate, g/d	0.02	(0.01, 0.03)	**<0.001**	0.01	(0.004, 0.03)	**0.01**	0.02	(0.01, 0.03)	**0.01**
Carbohydrate, %E	-0.09	(-0.16, -0.02)	**0.01**	-0.10	(-0.15, -0.04)	**0.002**	-0.09	(-0.16, -0.03)	**0.004**
Carbohydrate, g/kg/d	-0.29	(-0.46, -0.13)	**<0.001**	-0.26	(-0.42, -0.10)	**0.002**	-0.23	(-0.40, -0.06)	**0.01**
Protein									
Protein, g/d	0.06	(0.03, 0.09)	**<0.001**	0.05	(0.02, 0.08)	**0.01**	0.05	(0.02, 0.08)	**0.004**
Protein, %E	-0.12	(-1.7, -0.44)	0.1	-0.09	(-0.22, 0.05)	0.2	-0.07	(-0.21, 0.07)	0.3
Protein, g/kg/d	-1.06	(-1.7, -0.44)	**<0.001**	-0.73	(-1.32, -0.13)	**0.02**	-0.56	(-1.19, 0.08)	0.1
Fat									
Fat, g/d	0.07	(0.05, 0.08)	**<0.001**	0.06	(0.04, 0.07)	**<0.001**	0.06	(0.04, 0.07)	**<0.001**
Fat, %E	0.12	(0.05, 0.18)	**<0.001**	0.11	(0.06, 0.17)	**<0.001**	0.11	(0.05, 0.16)	**0.001**
Fat, g/kg/d	0.12	(-0.35, 0.60)	0.6	0.34	(-0.12, 0.80)	0.2	0.32	(-0.14,0.79)	0.2

Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d Per kilogram of body weight per day

[1] Linear regression

[2] Linear regression adjusted for Age, Sex, Maternal Educational level, Mother BMI, Father BMI, Mother age, Father Age, Social Class

[3] Linear regression adjusted Age, Sex, Maternal Educational level, Mother BMI, Father BMI, Mother age, Father Age, Social Class, and Physical Activity

Significance $p<0.05$

Table 8-5 Associations between energy and macronutrient intake with overweight/obesity

	Not OWT/OB (n=54)		OWT/OB (n=5)		p[1]	OR (95% CI)[2, 3]		p
Energy								
Total energy, kcal/d	1294.2	(153.5)	1802.1	(127.4)	**<0.001**	1.03	(1.00, 1.05)	0.05
Energy, kcal/kg/d	80.2	(10.4)	74.6	(4.5)	0.2	0.93	(0.84, 1.04)	0.2
Carbohydrates								
Carbohydrate, g/d	167.0	(23.2)	227.9	(13.3)	**<0.001**	1.17	(1.01, 1.36)	**0.04**
Carbohydrates, %E	52.9	(4.1)	52.2	(4.4)	0.7	0.96	(0.77, 1.20)	0.7
Carbohydrate, g/kg/d	10.4	(1.6)	9.5	(1.3)	0.3	0.67	(0.35, 1.31)	0.2
Protein								
Protein, g/d	45.2	(7.5)	58.0	(6.8)	**0.01**	1.23	(1.05, 1.43)	**0.01**
Protein, %E	15.3	(2.1)	14.1	(1.3)	0.2	0.72	(0.42, 1.22)	0.2
Protein, g/kg/d	2.8	(0.4)	2.4	(0.4)	0.1	0.10	(0.01, 1.20)	0.1
Fat								
Fat, g/d	54.0	(10.3)	79.4	(15.0)	**<0.001**	1.16	(1.05, 1.28)	**0.004**
Fat, %E	31.8	(4.2)	33.7	(4.8)	0.4	1.11	(0.90, 1.36)	0.4
Fat, g/kg/d	3.3	(0.7)	3.3	(0.3)	0.8	0.77	(0.16, 3.8)	0.7

Data are mean (SD) unless indicated. Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d per kilogram of body weight per day; OWT/OB, overweight/obese.

[1] Independent samples t-test for mean differences between genders.

[2] Logistic regression to test association between energy and nutrient intake and overweight and obesity as a binary outcome.

[3] Multivariate analyses were not carried out, due to the small sample size

Significance set at p<0.05

Table 8-6 Subject characteristics according to quintiles of Traditional/healthy dietary pattern score

	n	Q1[1]	n	Q2	n	Q3	n	Q4	n	Q5	p[2]
Dietary pattern score	12	-0.7(0.1)	12	-0.5(0.1)	12	-0.2(0.1)	11	0.1(0.1)	12	1.3(1.6)	
Gender, % male		67		58		58		72		58	0.9
Age, years	12	4.0 (0.5)	12	4.2 (0.9)	12	4.8(0.6)	11	4.3(1.0)	12	4.6 (0.7)	0.1
Education, with degree, % (n)	12	58(7)	12	75(9)	12	42(5)	11	64(7)	12	67(8)	0.6
Social class, non-manual,% (n)	12	83(10)	12	92(11)	12	92(11)	11	91(10)	12	92(11)	0.7
Physical activity, hrs/wk	12	12.3(6.8)	12	11.7(5.5)	12	11.7(8.6)	11	8.9(3.3)	12	9.3(3.5)	0.5
Sedentary behaviour, hrs/wk	12	10.3(7.6)	12	13.1(8.5)	12	14.2(7.3)	11	12.8(9.6)	12	13.8(8.6)	0.8
BMI z-score	12	-0.1(1.6)	12	-0.2(0.8)	12	-0.1(1.3)	11	-0.2(0.9)	12	-0.0(1.0)	1.0
Waist circumference, cm	12	52.2 (8.0)	12	51.3(3.3)	12	54.7(4.4)	11	52.8(4.5)	12	53.2(3.5)	0.6
Sum of skinfold, mm	12	30.2(10.9)	12	26.9(3.9)	11	32.9(13.4)	11	27.1(7.0)	12	30.1(5.4)	0.5
Systolic blood pressure, mmHg	10	100.9(8.1)	12	96.5(8.6)	12	96.5(4.3)	11	98.0(5.3)	11	95.9(5.9)	0.4
Diastolic blood pressure, mmHg	10	60.5(9.60)	12	59.4(5.7)	12	58.4(5.2)	11	58.6(4.4)	11	58.1(4.3)	0.9
Resting heart rate, beats/min	10	109.3(10.7)	12	103.1(11.3)	12	100.0(8.3)	11	104.8(11.1)	11	99.5(11.6)	0.1

Data are mean (SD) unless indicated.
[1] Lowest quintile for dietary pattern score
[2] p for trend across quintiles calculated with the dietary pattern score modelled on a continuous scale in general linear models.
Significance set at $p<0.05$

Table 8-7 Subject characteristics according to quintiles of Processed/western dietary pattern score

	n	Q1[1]	n	Q2	n	Q3	n	Q4	n	Q5	p[2]
Dietary pattern score	12	-0.9(0.2)	12	-0.5(0.1)	12	-0.2(0.1)	11	0.2(0.2)	12	1.4(1.3)	
Gender, % male		58		92		33		55		75	**0.04**
Age, years	12	4.1(1.0)	12	4.3(0.7)	12	4.6(0.5)	11	4.4(0.8)	12	4.5(0.7)	0.5
Education, with degree, % (n)	12	67(8)	12	50(6)	12	58(7)	11	55(6)	12	75(9)	0.8
Social class, non-manual, % (n)	12	100(12)	12	75(9)	12	83(10)	11	100(12)	12	100(12)	0.1
Physical activity, hrs/wk	12	9.9(4.7)	12	14.0(8.4)	12	11.1(6.3)	11	10.8(4.8)	12	8.2(2.7)	0.2
Sedentary behaviour, hrs/wk	12	14.9(9.1)	12	14.1(9.9)	12	11.3(6.9)	11	9.6(5.7)	12	14.3(8.4)	0.5
BMI z-score	12	0.1(0.9)	12	-0.5(0.9)	12	-0.3(1.2)	11	0.5(1.5)	12	-0.3(0.9)	0.2
Waist circumference, cm	12	52.4(3.7)	12	52.1(3.5)	12	53.5(5.0)	11	54.2(8.1)	12	52.1(4.3)	0.8
Sum of skinfold, mm	12	29.8(8.8)	12	26.5(4.2)	11	30.6(11.6)	11	33.1(11.1)	12	27.6(5.6)	0.4
Systolic blood pressure, mmHg	12	93.9(7.4)	9	97.5(6.8)	12	100.4(5.4)	11	99.6(7.8)	12	96.1(3.9)	0.1
Diastolic blood pressure, mmHg	12	57.1(5.6)	9	58.1(5.8)	12	59.3(7.4)	11	60.4(5.9)	12	59.9(4.9)	0.7
Resting heart rate, beats/min	12	102.6(10.6)	9	101.3(11.3)	12	102.8(10.3)	11	109.1(9.5)	12	100.7(10.4)	0.4

Data are mean (SD) unless indicated.
[1] Lowest quintile for dietary pattern score
[2] p for trend across quintiles calculated with the dietary pattern score modelled on a continuous scale in general linear models.
Significance set at $p<0.05$

Table 8-8 Subject characteristics according to quintiles of Convenience/Snack dietary pattern score

	n	Q1[1]	n	Q2	n	Q3	n	Q4	n	Q5	p[2]
Dietary pattern score	12	-1.0(0.3)	12	-0.5(0.1)	11	-0.2(0.1)	12	0.2(0.1)	12	1.4(1.3)	
Gender, % male		58		58		46		67		83	0.4
Age, years	12	4.2(0.6)	12	4.5(0.7)	11	4.1(0.8)	12	4.5(0.9)	12	4.5(0.7)	0.6
Education, with degree, % (n)	12	67(8)	12	42(5)	11	36(4)	12	58(7)	12	100(12)	**0.01**
Social class, non-manual, % (n)	12	92(11)	12	92(11)	11	100(11)	12	100(12)	12	75(9)	0.2
Physical activity, hrs/wk.	12	9.9(6.3)	12	11.7(6.2)	11	10.2(4.8)	12	13.4(7.0)	12	8.8(4.4)	0.3
Sedentary behaviour, hrs/wk	12	8.9(2.7)	12	14.6(9.8)	11	14.8(8.0)	12	14.5(9.7)	12	11.9(8.3)	0.3
BMI z-score	12	-0.0(1.2)	12	-0.1(1.0)	11	0.1(1.2)	12	0.0(1.4)	12	-0.4(0.8)	0.8
Waist circumference, cm	12	52.5(5.1)	12	53.1(4.9)	11	52.2(3.8)	12	53.8(7.7)	12	52.4(2.9)	0.9
Sum of skinfold, mm	12	29.4(11.6)	11	28.1(5.3)	11	30.6(8.4)	12	31.2(11.4)	12	27.6(5.6)	0.8
Systolic blood pressure, mmHg	12	99.7(6.6)	11	98.1(4.6)	11	95.6(6.2)	11	97.5(9.7)	11	96.2(5.1)	0.6
Diastolic blood pressure, mmHg	12	58.7(6.9)	11	58.1(5.6)	11	59.8(5.2)	11	57.5(6.9)	11	60.7(5.0)	0.7
Resting heart rate, beats/min	12	102.8(10.8)	11	105.1(9.9)	11	108.6(10.8)	11	98.7(10.7)	11	101.3(10.2)	0.2

Data are mean (SD) unless indicated.
[1] Lowest quintile for dietary pattern score
[2] p for trend across quintiles calculated with the dietary pattern score modelled on a continuous scale in general linear models.
Significance set at $p<0.05$

Table 8-9 Median score per diet score component of children

	Median score[1] (n=59)
Vegetables	0.2
Fruit	0.2
Bread	0.3
Rice, pasta and legumes	0.9
Dairy	0.2
Meat, egg and poultry	0.9
Fish	0.3
Oils and fats	0.1
Candy	0
Sugar sweetened beverages	0.1

Data are mean (SD)
[1]Scores standardised to 1200 kcal/day
Individual dietary component scores are ranked between 0 and 1, where 1 denotes a healthier diet (higher consumption of desirable foods, and lower consumption of lower dietary quality foods).

Figure 8-1 Histogram of dietary score standardised to 1200 kcal per day

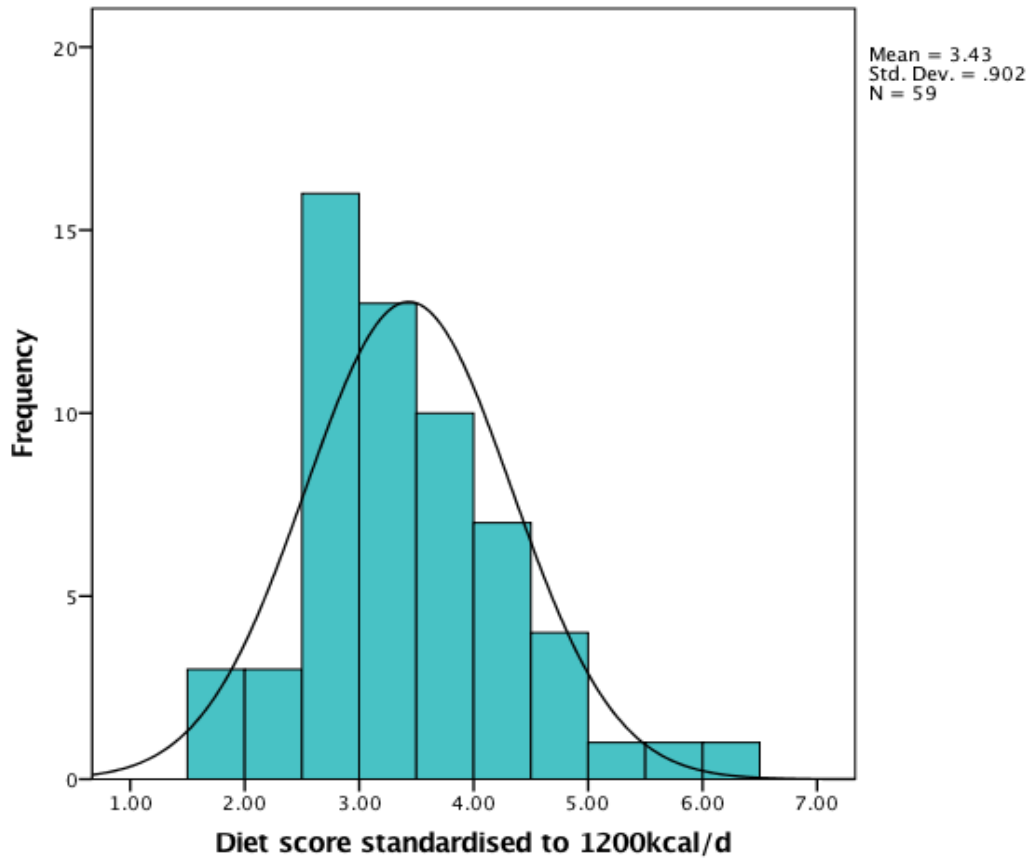


Table 8-10 Subject characteristics according to quintiles of diet score

	n	Q1[1]	n	Q2	n	Q3	n	Q4	n	Q5	p[2]
Diet score	12	2.5	11	2.9	13	3.3	12	3.7	11	4.8	
Gender, % male		58		73		46		67		73	0.6
Age, years	12	4.0(0.7)	11	4.2(0.8)	13	4.4(0.6)	12	4.5(0.7)	11	4.8(0.8)	0.2
Education, with degree, % (n)	12	33(4)	11	55(6)	13	77(10)	12	67(8)	11	73(8)	0.2
Social class, non-manual, % (n)	12	100(12)	11	91(10)	13	92(12)	12	92(11)	11	82(9)	0.7
Physical activity, hrs/wk.	12	14.0(7.9)	11	11.5(7.2)	13	8.6(3.1)	12	9.9(5.6)	11	10.2(3.7)	0.2
Sedentary behaviour, hrs/wk.	12	13.2(9.0)	11	11.0(8.0)	13	10.2(5.6)	12	16.9(9.4)	11	13.5(8.0)	0.3
BMI z-score	12	0.2(1.4)	11	-0.5(0.5)	13	-0.3(1.2)	12	0.1(1.2)	11	-0.1(1.0)	0.5
Waist circumference, cm	12	53.7(8.2)	11	51.1(2.1)	13	51.9(4.6)	12	53.6(4.7)	11	53.8(3.3)	0.6
Sum of skinfold, mm	11	30.1(11.5)	11	26.0(4.1)	13	28.9(5.2)	12	32.9(13.3)	11	28.9(5.6)	0.5
Systolic blood pressure, mmHg	12	99.3(8.3)	10	98.5(7.6)	12	98.2(5.4)	12	95.9(5.9)	10	95.2(5.4)	0.5
Diastolic blood pressure, mmHg	12	58.8(5.9)	10	58.5(5.5)	12	61.5(6.3)	12	57.4(4.7)	10	58.4(5.5)	0.5
Resting heart rate, beats/min	12	107.4(9.2)	10	99.6(11.9)	12	104.4(10.4)	12	100.5(11.0)	10	103.8(10.8)	0.4

Data are mean (SD) unless indicated.
[1] Lowest quintile for dietary pattern score
[2] p for trend across quintiles calculated with the diet score modelled on a continuous scale in general linear models.

Table 8-11 Regression coefficients (95% CI) for BMI z-score according to quintiles of dietary pattern score[1]

	Q2	p[2]	Q3	p[2]	Q4	p[2]	Q5	p[2]	p[3]
Health conscious/Traditional									
Model 1	-0.1(-1.0, 0.9)	0.9	-0.0(-1.0, 0.9)	1.0	-0.1(-1.1,0.9)	0.9	0.1(-0.9,1.0)	0.9	1.0
Model 2	-0.1(-0.7, 0.5)	0.8	0.2(-0.5, 0.8)	0.6	-0.1(-0.7, 0.5)	0.8	0.1(-0.5, 0.7)	0.8	0.9
Processed/westernised									
Model 1	-0.6(-1.5, 0.3)	0.2	-0.4(-1.3, 0.5)	0.4	0.4(-0.5, 1.3)	0.4	-0.5(-1.4, 0.4)	0.3	0.2
Model 2	0.3(-0.4, 0.9)	0.4	0.1(-0.5, 0.7)	0.7	0.6(-0.0, 1.2)	0.07	0.2(-0.4, 0.8)	0.5	0.4
Convenience									
Model 1	-0.1(-1.0, 0.9)	0.9	0.1(-0.9, 1.1)	0.8	0.1(-0.9,1.0)	0.9	-0.4(-1.3,0.5)	0.4	0.8
Model 2	-0.0(-0.6, 0.6)	1.0	0.1(-0.6, 0.7)	0.8	0.0(-0.6, 0.6)	0.9	-0.2(-0.9, 0.4)	0.5	0.9

[1] Quintile 1 is the lowest for dietary pattern score (referent set at 0).
[2] Beta coefficient values are calculated as highest minus lowest quintiles based on general linear models
Model 1: Unadjusted
Model 2: Adjusted for age, sex, maternal BMI, maternal educational level, energy intake,
[3] p for trend across quintiles calculated in GLM with dietary pattern modelled continuously (score).

Table 8-12 Regression coefficients (95% CI) for BMI z-score according to quintiles of Diet score[1]

	Q2	p[2]	Q3	p[2]	Q4	p[2]	Q5	p[2]	p[3]
Model 1	-0.8 (-1.7, 0.2)	0.1	-0.5 (-1.4, 0.5)	0.3	-0.1 (-1.0, 0.8)	0.8	-0.3 (-1.3, 0.6)	0.5	0.5
Model 2	-0.3 (-0.9, 0.3)	0.4	-0.4 (-1.0, 0.2)	0.2	0.2 (-0.5, 0.8)	0.6	-0.0 (-0.7, 0.6)	1.00	0.3

[1] Quintile 1 is the lowest for diet score (referent set at 0).
[2] Beta coefficient values are calculated as highest minus lowest quintiles based on general linear models,
Model 1: Unadjusted
Model 2: Adjusted for age, sex, maternal BMI, maternal educational level, energy intake
[3] p for trend across quintiles calculated in GLM with diet score modelled continuously.

Table 8-13 Pearson's correlation coefficient between *a priori* Diet Score and PCA derived dietary patterns

	r	p
Traditional/health conscious[1]	0.558	**<0.001**
Processed/western[1]	0.081	0.5
Convenience/snack[1]	0.194	0.1

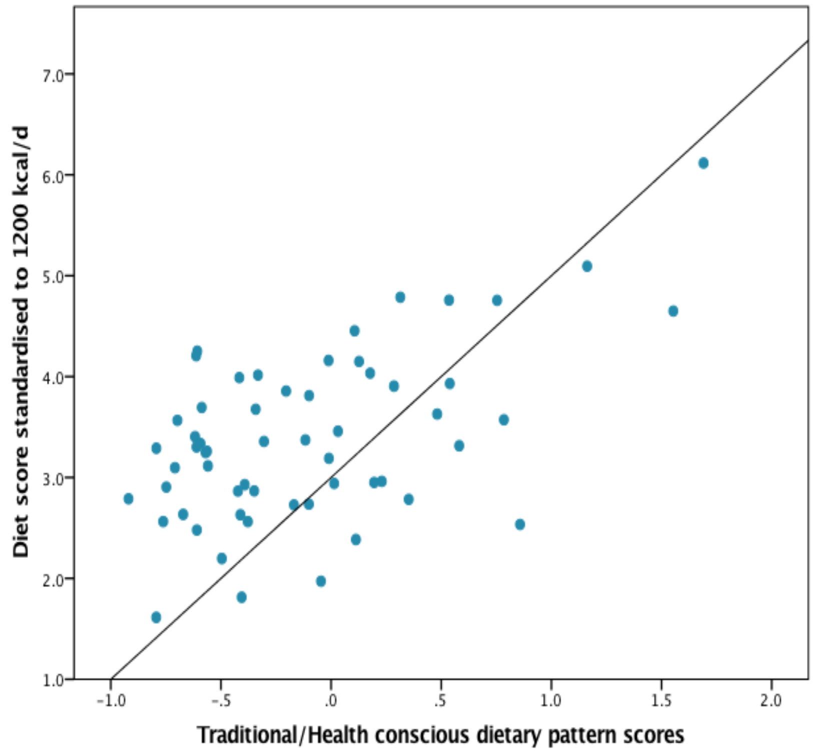
p-values for significant correlation (p<0.05) are shown in bold
[1]Dietary patterns derived using PCA

Table 8-14 Agreement between children classified into thirds for diet score and PCA-derived dietary patterns

	Diet score			
	Exact (%)	GM	k	p
Traditional/health-conscious	60	15	0.24	**0.01**
Processed/western[1]	26	33	0.01	0.9
Convenience/snack[1]	32	36	-0.04	0.7

GM, Gross misclassification, k; kappa, Significance p<0.05
[1]Dietary patterns derived using PCA

Figure 8-2 Scatterplot of *a priori* Diet Score and PCA derived Traditional/health-conscious dietary pattern



Chapter 9 Study 3 Results: Effectiveness of a simple lifestyle tool: Findings of a randomised controlled trial

The secret of change is to focus all of your energy, not on fighting the old, but on building the new – Socrates

9.1 Introduction

As reviewed in Chapter 4 (see section 4.5), studies focused on preschool children in the UAE are limited, and no study, to date, has investigated the effectiveness of interventions aimed at preventing the development of preschool overweight and obesity. Therefore, in consideration of the lack of research in the field and potential influence of cultural factors, the current research aimed to investigate the efficacy of a simple educational tool: 'Eat Right Emirates: 10 Steps for Healthy Toddlers' to encourage a healthy lifestyle and potentially prevent preschool obesity (see section 6.9.1 for a description of the intervention).

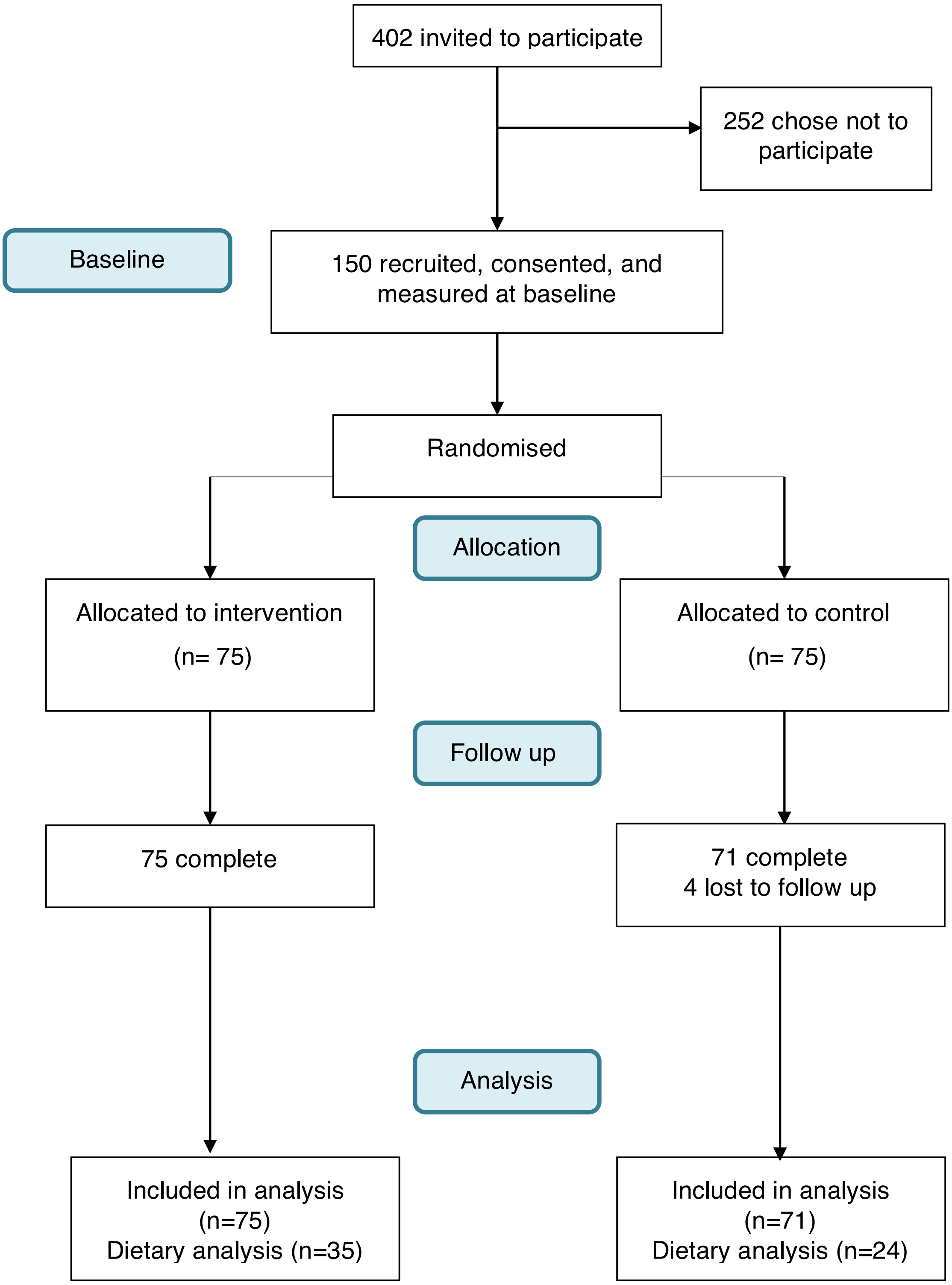
9.2 Results

As described in Chapter 6, measurements before the intervention (baseline) took place between October 2014 and January 2015. Follow-up measurements were completed between March 2015 and June 2015, at the end of the six month intervention. A total of 150 children were randomised to control (n=75) or intervention (n=75) at baseline. Figure 9-1 shows the flow of participants through the study. Complete dietary data was available for 59 children: 35 in the intervention group and 24 in the control group.

9.3 Response rates and trial dropout rates

The response rate of study participants was calculated using the number in each randomised group (intervention or control) with valid data at both study baseline and 6-month follow-up (end of intervention). At 6-month follow-up, response rates for participants in the intervention group ranged between 47% for dietary data and 92% to 100% for all other outcome variables (socio-demographic, parental, anthropometric, cardiovascular, behavioural factors).

Figure 9-1 Flow of participants through the study



Correspondingly, response rates for the control group ranged from 32% for dietary data to 91% to 95% for all other remaining outcome variables. Overall, all children (100%) in the intervention group were measured at 6-month follow-up, while, in the control group, 95% of children were measured.

9.3.1 Baseline characteristics of trial population

Fifty seven percent of the children were boys and the average age of children was 4.4 (SD 0.8) years. There were no significant differences in any socio-demographic, anthropometric, cardiovascular, behavioural and dietary variables between the intervention and control group at baseline (Table 9-1).

9.3.1.1 Anthropometric and cardiovascular characteristics

Overall, children were normal weight, with a mean (SD) BMI z-score of 0.0 (1.1), with a mean (SD) waist circumference of 52.9 (4.5) cm. Mean systolic and diastolic blood pressures were 96.5 mmHg and 58.0 mmHg respectively, and mean resting heart rate was 103 beats per minute (Table 9-2).

9.3.1.2 Behavioural characteristics

Baseline behavioural characteristics are presented in Table 9-3. On average, children took part in 11.1 hours of physical activity per week (approximately an hour and a half per day), spent 12.4 hours per week (approximately 2 hours per day) watching television or playing on computer video games (e.g. iPads), and slept for 9.6 hours per night.

Behavioural characteristics (activity and dietary related) measured using a 10-point Likert scale (see section 6.8.8.3) are also presented in Table 9-3**.** Scores for activity behaviour, eating behaviour, enjoyment of food and helpings of fruits and vegetables did not differ between randomised groups at baseline.

9.3.1.3 Dietary characteristics

Fifty-nine children had complete dietary data at both baseline and follow-up (intervention: 35, control: 24). At baseline, mean energy intake of children was

1337 kcal per day. Children obtained 53% energy from carbohydrate, 15% from protein, and 32% from fat (Table 9-4).

The mean total diet quality score[26] for children at baseline was 3.1, where 0 represents a low quality diet and 10 represents a high diet quality. There was no difference in dietary intakes or diet scores between randomised groups at baseline (Table 9-5).

9.4 Comparison of randomised groups at 6 months

Comparison between randomised groups at the end of the intervention (6-month follow-up) are presented in Tables 9-6 to 9-9. Overall, at 6 months from study baseline, children in the intervention group displayed favourable improvements in outcomes including anthropometry, body composition, behavioural factors and dietary intake, compared to controls.

Change within subjects between baseline and 6 months is presented in Tables 9-10 to 9-13. Within subjects change in study outcomes also showed positive effects in the intervention group compared to controls.

9.4.1 Anthropometry

Randomised comparisons

Unadjusted and adjusted comparison between randomised groups at 6-month follow-up are presented in Table 9-6. In unadjusted models, there was no difference in anthropometric outcomes between randomised groups at 6 months (Figure 9-2). However, in the adjusted model, BMI z-score (adjusted for age, sex and baseline BMI z-score) was significantly lower at the 6-month follow-up in the intervention group compared to the control group (mean difference: -0.24; 95% CI: -0.38 to -0.06; p=0.007) (Table 9-6). BMI (kg/m^2), weight (kg) and weight z-score adjusted for age, sex and corresponding baseline variables were

[26] The sum of each dietary component score was used to calculate total diet quality score (Voortman et al., 2015) (see section 6.10.1.2.4).

significantly lower in the intervention group compared with the control group at 6-month follow-up from study baseline (Table 9-6).

<u>Within subject change</u>

With respect to within subject changes, the primary outcome (change in BMI z-score) was significantly different in the intervention group compared to controls (mean difference: -0.26; 95% CI: -0.43 to -0.09). BMI z-score increased in the control group (mean difference: 0.40; 95% CI: 0.29 to 0.51; $p<0.001$) between study baseline and 6-month follow-up. However, no significant changes in BMI z-score were observed in the intervention group (mean difference: 0.14; 95% CI: -0.01, 0.28; $p=0.1$)(Table 9-10). These data imply that while BMI z-score increased in both randomised groups, the increase was greater in the control group compared to the intervention group. All remaining anthropometric variables were altered favourably in the intervention group, but the benefits did not reach statistical significance.

9.4.2 Body composition

<u>Randomised comparisons</u>

There were no significant differences in body composition (sum of skinfold thickness) between randomised groups at 6-month follow-up in both adjusted and unadjusted models (Table 9-6).

<u>Within subject change</u>

No significant differences in body composition were found for within subject change between randomised groups (Table 9-10).

9.4.3 Cardiovascular health

<u>Randomised comparisons</u>

By chance, systolic and diastolic blood pressure was found to be higher in the intervention group compared to controls at 6-month follow-up (Table 9-6).

Within subject change

In relation to within subject changes, although change in systolic and diastolic blood pressure was not statistically different between randomised groups at six months from baseline (systolic blood pressure mean difference: 2.39 mmHg, 95% CI: -0.81 to 5.60; p=0.1, diastolic blood pressure mean difference: 1.44 mmHg, 95% CI: -1.53 to 4.42; p=0.3), unexpectedly the within subject change in both systolic and diastolic blood pressure reached significance for children in the intervention group (Table 9-10).

9.4.4 Activity-related behaviour

Randomised comparisons

Unadjusted and adjusted comparisons between randomised groups at 6 month follow-up are presented in Table 9-7. At 6 months, following intervention, physical activity (hours per week) was greater in the intervention group compared to controls (mean difference: 2.67 hours/week; 95% CI: 0.92 to 4.41; p<0.001) in the unadjusted model. This difference remained significant after adjusting for baseline physical activity, age and sex (mean difference: 3.22 hours/week; 95% CI: 1.77 to 4.67; p<0.001).

Time spent in sedentary behaviours (e.g. TV viewing or using electronic devices) was significantly lower in the intervention group compared with controls at the end of the intervention (mean difference: -4.58 hours/week; 95% CI: -6.84 to -2.32; p=0.003). This difference also remained significant after adjusting for age, sex and baseline sedentary behaviour (mean difference: -3.67 hours/week; 95% CI: -5.15 to -2.19; p<0.001)(Table 9-7).

Within subject change

Within subject change from baseline to 6 months follow-up showed similar findings (Table 9-11). Within subject change for physical activity between randomised groups was greater in the intervention group compared to controls at 6-month follow-up (mean difference: 3.75 hours/week; p<0.001), and sedentary behaviour was lower in the intervention group compared to controls (mean difference: -3.05 hours/week; p<0.001).

Children in the intervention group spent more time in physical activities (mean difference: 3.36 hours per week; 95% CI: 2.11 to 4.61; p<0.001), and less time in sedentary behaviours (mean difference: -1.68 hours per week; 95% CI: -2.89 to 0.475; p=0.01). However, in the control group children spent more time in sedentary activities (mean difference: 1.37 hours per week; 95% CI: 0.17 to 2.56; p=0.03) at 6-month follow-up from baseline (Table 9-11).

9.4.5 Sleep duration

Randomised comparisons

At the end of the 6-month intervention, sleep duration (hours per day) was significantly higher in the intervention group compared with controls in both the unadjusted and adjusted models (Table 9-7) In the unadjusted model, sleep duration was 0.4 hours greater compared with controls (95% CI: 0.03 to 0.83; p=0.04). This difference between randomised groups remained significant after adjusting for age, sex and baseline sleep duration (mean difference: 0.40 hours per day; 95% CI: 0.09 to 0.72; p<0.001).

Within subject change

In relation to change within subjects no difference for sleep duration between randomised groups was observed (mean difference: 0.36; 95% CI: -0.03 to 0.74; p=0.1). However, sleep duration in the control group was -0.32 hours per day lower, compared to baseline (95% CI: -0.58 to -0.07; p=0.01). No change within subjects in the intervention group was observed (p=0.9) (Table 9-11).

9.4.6 Diet-related behaviour

Randomised comparisons

Behaviours related to diet significantly improved in the intervention group relative to control for both unadjusted and adjusted analyses. Children in the intervention group scored higher for enjoyment of food (i.e. enjoy tasting new foods, a variety of foods including fruit and vegetables) and general eating behaviour (i.e. child is easy to feed, calm, attentive and eats slowly). Servings of fruit and vegetables per day were also found to be significantly greater in the intervention group compared with controls at 6-month follow-up from study baseline (1.9 v 1.0 servings per day; p<0.001) (Table 9-7).

Within subject change

Within subject changes between randomised groups in favour of the intervention were also observed for eating behaviour (p=0.02), enjoyment of food (p<0.001) and helpings of fruits (p<0.001). Change within subjects in diet-related behaviour scores was only seen in the intervention group, suggesting that the intervention influenced enjoyment of food and eating behaviour scores (Table 9-11).

9.4.7 Dietary intake

As presented in Tables 9-8 and 9-12, the Eat Right Emirates intervention tool significantly influenced energy and macronutrient intake of children in the intervention group.

9.4.7.1 Energy intake

Randomised comparisons

After 6 months, following intervention, energy intake was lower in the intervention group, compared to the control group, in both unadjusted and adjusted models. In the unadjusted model, energy intake was -139.8 kcal lower in the intervention group compared to controls (95% CI: -240.6 to -35.9; p=0.01). The difference between randomised groups after adjusting for age, sex and baseline energy intake remained significant (adjusted mean difference: -121.7 kcal/day; 95% CI: -167.2 to -76.3; p<0.001) (Table 9-8). Relative energy intake (per kilogram body weight) was -7.5 kcal/kg lower in the intervention group compared to controls in the unadjusted model, and the difference between randomised groups remained following the adjustment for age, sex and baseline energy intake per kilogram body weight (mean difference: -4.5 kcal/kg/d; 95% CI: -8.1 to 0.9; p=0.02)(Table 9-8).

Within subject change

At 6 month follow-up within subject change in absolute energy intake (kcal per day) differed between randomised groups (mean difference: -115.1 (95% CI -162.9 to -67.4; p<0.001). In the intervention group, within subject absolute energy intake (kcal per day) was significantly lower at 6 month follow-up compared with study baseline (mean difference: -54.1 kcal/day; 95% CI: -82.5 to 25.6; p<0.001). Total energy intake was significantly higher in the controls at 6 months from baseline (mean difference: 61.1 kcal/day; 95% CI: 18.9 to 103.2; p=0.01).

Relative energy intake within subject change also differed between randomised groups (mean difference: -3.97 kcal/kg; 95% CI: -7.47 to -0.46; p=0.03). In both groups, relative energy intake was lower at follow-up compared to study baseline. However, this reached significance only in the intervention group (mean difference: -7.15 kcal/kg/d; 95%CI: -9.12 to -5.19; p<0.001)(Table 9-12).

9.4.7.2 Carbohydrate intake

Randomised comparisons

There was no difference between randomised groups in the unadjusted models for carbohydrate intake (Table 9-8). However, following adjustment for baseline carbohydrate intake in grams per day, age and sex, absolute intake of carbohydrates (grams per day) was significantly lower in the intervention group compared to control (mean difference: -14.9; 95% CI: 26.0 to -3.8; p=0.01).

No differences between randomised groups were found for relative and energy adjusted carbohydrate intake at 6 month follow-up.

Within subject change

At 6 month follow-up within subject change in absolute carbohydrate intake differed between randomised groups (mean difference: -13.7; 95% CI: -25.5 to -1.81; p=0.03). Within subjects absolute carbohydrate intake significantly increased in the control group (p=0.01) but not in the intervention group (p=0.8). Carbohydrate intake adjusted for body weight decreased in the intervention group at 6 month follow-up compared with baseline (mean difference: -0.5 g/kg; 95% CI: -0.9 to -0.1; p=0.03). However, energy adjusted carbohydrate intake was significantly greater in the intervention group, by 2% (95% CI: 0.5 to 3.5; p=0.01), but not in the control group (Table 9-12).

9.4.7.3 Protein intake

Randomised comparisons

Protein intake was higher in the intervention group compared with controls at 6-month follow-up from study baseline (mean difference: 5.3 grams per day; 95% CI: 0.4 to 10.2; p=0.03). This remained significant after adjusting for baseline protein intake, age and sex. Differences between randomised groups at 6 months follow-up were also found for protein as a percentage of energy and relative to body size (grams per kilogram body weight) (Table 9-8).

Within subject change

At 6 month follow-up, within subject change in absolute, energy adjusted and relative protein intake differed between randomised groups (Table 9-12). In the intervention group, both absolute and energy adjusted protein intake increased at 6 month follow-up from baseline. Absolute energy intake was 4.0 grams greater (95% CI: 1.4 to 6.7; p=0.003) and energy adjusted protein intake increased by 1.8% (95% CI: 0.9 to 2.7; p<0.001) in the intervention group at 6-month follow-up. However, in the control group, both energy adjusted protein intake (mean difference: -1.3% ; 95% CI -2.2 to -0.3; p=0.01), and relative protein intake (mean difference: -0.33 (95% CI: -0.52 to -0.13; p=0.002) decreased at 6 month follow-up from baseline (Table 9-12)

9.4.7.4 Fat intake

Randomised comparisons

Absolute, relative and energy adjusted fat intake was significantly lower in the intervention group compared with controls at 6 month follow-up in both unadjusted and adjusted analyses. At 6 months, following intervention, energy adjusted fat intake was 4.1% lower (95% CI: -6.1 to -2.0; p<0.001) in the intervention group compared with controls. This difference remained significant after adjusting for baseline, sex and gender (mean difference: -3.6%; 95% CI: -5.5 to -1.6; p<0.001) (Table 9-8).

Within subject change

In relation to within subject change, fat intake was significantly different between randomised groups at 6 month follow-up. For energy adjusted fat intake within subject change was lower in the intervention group compared with controls (mean difference: -3.4%; 95% CI: 6.0 to -0.9; p<0.001). In the intervention group, fat intake as percentage of energy was significantly lower in the intervention group at 6-month follow-up relative to study baseline (mean difference: -3.8; 95% CI: -5.3 to -2.3; p<0.001). Similar findings were observed for absolute and relative fat intake adjusted for body weight (p<0.001)(Table 9-12).

9.4.8 Diet score

Randomised comparisons

Individual diet scores representing a healthier diet improved favourably in the intervention group compared with controls in both unadjusted and adjusted models (Table 9-9). At 6-month follow-up, almost all individual diet scores (except for the meat, egg and poultry diet score) were significantly different from baseline, and the total diet score was significantly greater in the intervention group compared with controls at the end of the intervention (adjusted mean difference: 2.69 (95% CI: 2.03 to 3.36; p<0.001) (Table 9-9).

Within subject change

With respect to within subject changes, individual diet score components favouring a better quality diet significantly increased in the intervention group at follow-up relative to study baseline. In particular, scores for less desirable foods (candy and sugar sweetened beverages) significantly increased [27] in the intervention group. The candy score was increased (i.e. lower consumption) in both the intervention (mean difference: 0.49; 95% CI: 0.33 to 0.64; $p<0.001$) and control group (mean difference: 0.14; 95% CI: 0.01 to 0.27; $p=0.04$). However, for sugar-sweetened beverages the score only increased significantly in the intervention group ($p<0.001$). Overall, the Eat Right Emirates intervention was associated with an increase in diet score i.e. diet quality improved between baseline and 6-month follow-up (Table 9-13).

9.5 Parental feedback on Eat Right Emirates intervention tool

Following completion of the study, parents (mainly mothers) in the intervention group provided feedback and rated the usefulness of the Eat Right Emirates tool (Tables 9-14 and 9-15). Overall, the mean rating of the usefulness of the intervention tool was 7.2 (highest score 10). Quotes were grouped to reflect similarities of feedback. Most mothers said that the leaflet was 'useful' and 'helpful' and provided positive feedback on the leaflet and accompanying five food group guide. There were some statements specifically related to portion sizes, suggesting that portion size information is useful, but many also showed an interest in more information, with comments such as: 'I benefited from the information but I would like more'; 'Information is limited, need more information on different food and recipes for children'.

9.6 Adverse effects

No adverse effects were reported.

[27] An increase in less desirable diet scores denotes a lower consumption, where 0 implies children consume more than the recommended intake of candy or sugar sweetened beverages, a ratio closer to 1 denotes that children are consuming less of these foods.

9.7 Summary of findings

In summary, the Eat Right Emirates healthy lifestyle tool had beneficial effects on the primary outcome BMI z-score, and improved behavioural and dietary outcomes. The low dropout rates and high rating of the intervention tool suggest that the simple intervention tool was well accepted.

Figure 9-2 Mean BMI z-score at baseline and follow-up according to randomised group

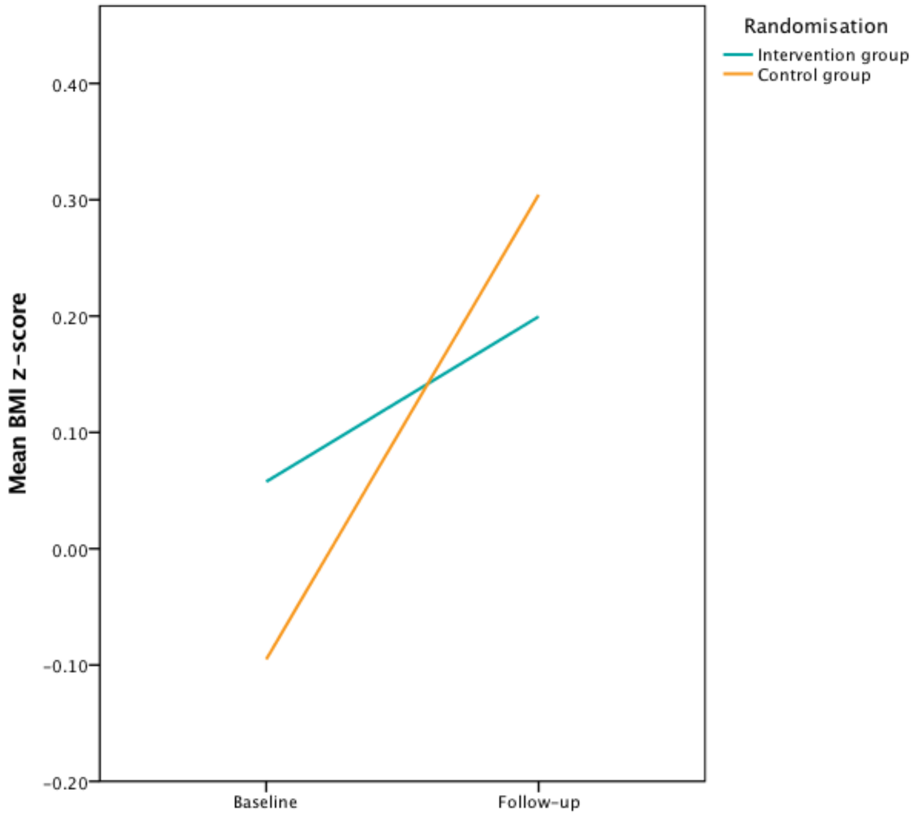


Table 9-1 Baseline socio-demographic, parental, pregnancy and birth characteristics of children

	All n=150		Intervention n=75		Control n=75		p[1]
Age, years	4.4	(0.8)	4.5	(0.8)	4.3	(0.8)	0.1
Gender: Male, % (n)[2]	57	(85)	55	(41)	59	(44)	0.7
Maternal							
Mother's age, y	32.9	(4.8)	32.9	(4.6)	32.8	(5.0)	0.9
Ethnicity, UAE: Ethnicity, % (n)[2]	96	(144)	96	(72)	96	(72)	1.0
Educational level: with degree, % (n)[2, 3]	55	(82)	53	(40)	56	(42)	0.9
Mother's BMI, kg/m^2 [3]	27.6	(5.0)	27.8	(5.0)	27.3	(5.0)	0.5
Domestic-helper, % (n)[2]	97	(145)	96	(72)	97	(73)	0.6
Parental							
Father's age, y [4]	37.0	(6.7)	36.7	(6.9)	37.2	(6.6)	0.6
Non-manual: Social class, % (n)[2, 3]	94	(141)	95	(71)	93	(70)	1.0
Father's BMI, kg/m^2 [4]	28.5	(5.0)	28.3	(4.1)	29.1	(4.9)	0.3
Pregnancy and Birth							
Parity	3.7	(1.7)	3.7	(1.7)	3.9	(1.7)	0.5
Birth order, % (n) [2]							
1st born	27	(40)	32	(24)	21	(16)	0.3
2nd born	29	(43)	26	(20)	31	(23)	
3rd and more	45	(67)	41	(31)	48	(36)	
Birth weight, kg	2.9	(0.5)	2.9	(0.5)	2.9	(0.5)	0.3

All data mean (SD) unless indicated; significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Comparison between dichotomous variables using Chi-squared test;
[3] < 3% missing data
[4] < 15% missing data

Table 9-2 Baseline anthropometric and cardiovascular characteristics of children

	All n=150		Intervention n=75		Control n=75		p[1]
Anthropometry							
Weight, kg	17.1	(3.2)	17.4	(2.9)	16.8	(3.4)	0.3
Weight z score	-0.1	(1.2)	-0.0	(1.0)	-0.1	(1.3)	0.6
Height, cm	104.9	(6.9)	105.7	(6.8)	104.1	(6.9)	0.1
Height z score	-0.1	(1.0)	-0.1	(0.9)	-0.2	(1.1)	0.7
BMI, kg/m^2	15.5	(1.7)	15.5	(1.6)	15.4	(1.8)	0.8
BMI z score	0.0	(1.1)	0.1	(1.1)	-0.0	(1.2)	0.7
Waist circumference, cm	52.9	(4.5)	53.2	(4.2)	52.6	(4.8)	0.4
Sum of skinfolds, mm [2, 3]	29.1	(1.3)	29.3	(1.2)	29.2	(1.3)	0.4
Cardiovascular							
Systolic blood pressure, mmHg [3]	96.5	(7.4)	96.9	(7.5)	96.0	(7.3)	0.5
Diastolic blood pressure, mmHg [3]	58.0	(6.7)	58.9	(6.3)	57.1	(6.9)	0.1
Resting heart rate, beats/min [3]	103.4	(11.1)	103.7	(11.6)	102.3	(10.5)	0.5

All data mean (SD); significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Log_e transformed, geometric mean (coefficient of variation)
[3] <3% missing data

Table 9-3 Baseline behavioural characteristics of children

	All n=150		Intervention n=75		Control n=75		p[1]
General behaviour							
Mood score [2]	18.3	(3.3)	18.5	(3.3)	18.2	(3.4)	0.5
Sleep duration, hrs/d	9.6	(1.5)	9.6	(1.6)	9.5	(1.3)	0.8
Diet related behaviour							
Eating behaviour score [2]	22.8	(5.0)	22.6	(4.8)	23.0	(5.1)	0.6
Appetite score [3]	36.7	(4.8)	37.1	(4.9)	36.4	(4.7)	0.4
Enjoyment of food score [2]	24.7	(9.3)	24.8	(9.9)	24.5	(9.0)	0.9
Helpings of fruit and vegetables per day	1.1	(1.0)	1.1	(1.1)	1.2	(1.0)	0.4
Activity related behaviour							
Active behaviour score [2]	34.5	(4.5)	34.0	(4.3)	35.0	(3.9)	0.2
Sedentary activity, hrs/wk.	12.4	(8.1)	11.5	(6.4)	13.3	(9.4)	0.2
Physical activity, hrs/wk.	11.1	(5.6)	10.5	(5.6)	11.6	(5.6)	0.3

Data are mean (SD); Significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Sum of score from 10 point Likert scale: higher score denotes a positive change except for appetite score[3]
Mood score ranges between 1-30 (maximum score: child is happy, does not get upset easily is communicative)
Active Behaviour score ranges between 1-70 (maximum score: child is active, energetic, and plays a lot)
Eating Behaviour score ranges between 1-40 (maximum score: child is easy, calm, attentive, slow during meals)
Appetite score ranges between 1-70 (maximum score: child has a big appetite, not full at end of meal, always asking for food (scores reversed))
Enjoyment of Food score ranges between 1-50 (maximum score: child enjoys tasting new foods, a variety of foods, enjoys fruits and vegetables)

Table 9-4 Baseline energy and macronutrient intake of children

	All n=59		Intervention n=35		Control n=24		p[1]
Energy							
Total Energy, kcal/d	1337.2	(207.4)	1327.8	(183.3)	1350.9	(241.8)	0.7
Energy, kcal/kg/d	79.7	(10.2)	78.3	(8.7)	81.8	(11.8)	0.2
Carbohydrates							
Carbohydrate, g/d	172.2	(28.2)	172.4	(29.3)	171.8	(26.9)	0.9
Carbohydrate, g/kg/d	10.3	(1.6)	10.2	(1.5)	10.5	(1.8)	0.5
Carbohydrate, %E/d	52.8	(4.1)	53.1	(4.3)	52.4	(3.9)	0.5
Protein							
Protein, g/d	46.3	(8.2)	46.2	(9.0)	46.4	(6.9)	0.9
Protein, g/kg/d	2.8	(0.4)	2.7	(0.4)	2.8	(0.4)	0.3
Protein, %E/d	15.2	(2.1)	15.2	(2.2)	15.2	(2.0)	1.0
Fat							
Fat, g/d	56.2	(12.7)	55.1	(9.7)	57.8	(16.3)	0.4
Fat, g/kg/d	3.3	(0.6)	3.2	(0.5)	3.5	(0.7)	0.2
Fat, %E/d	32.0	(4.2)	31.7	(4.0)	32.4	(4.6)	0.6

All data are mean (SD), Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d Per kilogram of body weight per day
[1] Comparison of randomised groups using independent t-test
Significance $p<0.05$

Table 9-5 Baseline Diet scores of children

	All n=59		Intervention n=35		Control n=24		p[1]
Vegetable score [2]	0.2	(0.2)	0.2	(0.2)	0.2	(0.2)	0.6
Fruit score [2]	0.2	(0.2)	0.2	(0.2)	0.2	(0.2)	0.5
Dairy score [2]	0.2	(0.1)	0.2	(0.1)	0.2	(0.2)	0.4
Bread score [2]	0.3	(0.3)	0.2	(0.3)	0.3	(0.4)	0.6
Rice, pasta, legumes score [2]	0.9	(0.2)	0.8	(0.2)	0.9	(0.2)	0.6
Meat, egg, poultry score [2]	0.9	(0.2)	0.8	(0.3)	1.0	(0.1)	**0.03**
Fish score [2]	0.3	(0.5)	0.4	(0.5)	0.2	(0.4)	0.1
Fats and oils score [2]	0.1	(0.2)	0.1	(0.1)	0.1	(0.2)	0.5
Sugar sweetened beverages score [3]	0.1	(0.2)	0.1	(0.2)	0.1	(0.2)	0.8
Candy score [3, 4]	0.0	(0.0)	0.0	(0.0)	0.0	(0.0)	-
Total diet score [4]	3.1	(0.9)	3.1	(0.9)	3.1	(0.9)	1.0

Data are mean (SD) Significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] scores calculated as a proportion of recommended intake, range between 0 and 1, where 1 denotes greater consumption
[3] scores calculated as a proportion of recommended intake, range between 0 and 1, where 1 denotes lower consumption
[4] All children exceeded their intake of candy (>25 g/d)
[5] Sum of individual diet score components, range between 0 and 10, where 10 denotes a healthier and higher diet quality diet

Table 9-6 Comparison of randomised groups for anthropometric and cardiovascular measures at 6-month follow-up

	Intervention n=75		Control n=71		Difference (unadjusted) [1]			Difference (adjusted) [2]		
					Mean (95% CI)		P	Mean (95% CI)		p
Weight, kg	18.3	(3.0)	18.2	(3.7)	0.18	(-0.92, 1.28)	0.7	-0.41	(-0.69, -0.12)	**0.01**
Weight z score	-0.1	(1.0)	-0.0	(1.2)	-0.02	(-0.40, 0.35)	0.9	-0.16	(-0.27, -0.04)	**0.01**
Height, cm	107.9	(6.7)	106.6	(7.0)	1.36	(-0.87, 0.59)	0.2	0.03	(-0.30, 0.35)	0.9
Height z score	-0.3	(0.9)	-0.4	(1.1)	0.04	(-0.27, 0.36)	0.7	-0.03	(-0.15,0.09)	0.7
BMI, kg/m^2	15.7	(1.5)	15.9	(1.8)	-0.18	(-0.73, 0.35)	0.5	-0.35	(-0.60, -0.11)	**0.01**
BMI z score	0.2	(1.0)	0.3	(1.1)	-0.10	(-0.45, 0.24)	0.6	-0.24	(-0.38, -0.06)	**0.007**
Waist circumference, cm	53.6	(4.0)	53.0	(4.9)	0.59	(-0.88, 2.05)	0.4	0.02	(-0.93, 0.99)	1.0
Sum of skinfolds, mm [3, 4]	30.7	(8.7)	29.3	(9.8)	1.43	(-1.60, 4.45)	0.4	0.01	(-1.61,1.64)	1.0
Systolic blood pressure, mmHg [4]	101.4	(7.4)	98.4	(8.9)	3.01	(0.31, 5.70)	**0.03**	2.52	(-0.04, 5.08)	**0.05**
Diastolic blood pressure, mmHg [4]	60.9	(6.5)	58.0	(7.9)	2.85	(0.48, 5.22)	**0.02**	2.43	(0.06, 4.79)	**0.04**
Resting Heart Rate, beats/min [4]	101.5	(10.6)	99.5	(11.8)	2.01	(-1.69, 5.72)	0.3	1.95	(-1.58, 5.48)	0.3

Data are mean (SD); BMI, body mass index; significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Linear regression adjusted for age, sex and corresponding baseline variable
[3] Log_e transformed, geometric mean (coefficient of variation)
[4] <3% missing data

Table 9-7 Comparison of randomised groups for behavioural measures at 6-month follow-up

	Intervention n=75		Control n=71		Difference (unadjusted) [1]			Difference (adjusted) [2]		
					Mean (95% CI)		p	Mean (95% CI)		p
General behaviour										
Mood score [3]	20.2	(3.4)	19. 2	(3.1)	1.0	(-0.07, 2.08)	0.1	0.84	(-0.21, 1.90)	0.1
Sleep duration, hrs/day	9.6	(1.3)	9.2	(1.2)	0.4	(0.03, 0.83)	**0.04**	0.40	(0.09, 0.72)	**<0.001**
Diet related behaviour										
Eating behaviour score [3]	24.0	(3.6)	22.5	(3.7)	1.5	(0.31, 2.70)	**0.01**	1.76	(0.62, 2.90)	**0.003**
Appetite score [4]	37.2	(3.8)	36.0	(4.3)	1.1	(-0.14, 2.51)	0.1	1.03	(-0.23, 2.28)	0.1
Enjoyment of food [3]	33.6	(5.7)	24.0	(5.8)	9.6	(7.75, 11.53)	**<0.001**	9.53	(7.69, 11.36)	**0.001**
Helpings of fruit and vegetables per day	1.9	(0.9)	1.0	(0.9)	0.8	(0.52, 1.12)	**<0.001**	0.88	(0.59, 1.17)	**<0.001**
Activity related behaviour										
Active behaviour score [3]	34.8	(3.4)	34.1	(4.8)	0.6	(-0.72, 2.01)	0.4	0.94	(-0.41, 2.29)	0.1
Sedentary activity, hrs/wk	9.8	(5.0)	14.4	(8.5)	-	(-6.84, -2.32)	**0.003**	-	(-5.15, -	**<0.001**
Physical activity, hrs/wk	13.9	(5.6)	11.2	(5.1)	2.6	(0.92, 4.41)	**<0.001**	3.22	(1.77, 4.67)	**<0.001**

Data are mean (SD); Significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Linear regression adjusted for age, sex and corresponding baseline variable
[3] Sum of score from 10 point Likert scale: higher score denotes a positive change except for appetite score[4]
Mood score ranges between 1-30 (maximum score: child is happy, does not get upset easily is communicative)
Active behaviour score ranges between 1-70 (maximum score: child is active, energetic, and plays a lot)
Eating behaviour score ranges between 1-40 (maximum score: child is easy, calm, attentive, slow during meals)
Appetite score ranges between 1-70 (maximum score: child has a big appetite, not full at end of meal, always asking for food (scores reversed))
Enjoyment of food score ranges between 1-50 (maximum score: child enjoys tasting new foods, a variety of foods, enjoys fruits and vegetables)

Table 9-8 Comparison of randomised groups for energy and macronutrient intake at 6-month follow-up

	Intervention n=35		**Control n=24**		**Difference (unadjusted)** [1]			**Difference (adjusted)** [2]		
					Mean (95% CI)		P	Mean (95% CI)		p
Energy										
Energy, kcal/d	1273.8	(150.2)	1412.1	(242.6)	-139.82	(-240.63, -35.93)	**0.01**	-121.74	(-167.23, -76.26)	**<0.001**
Energy, kcal/kg/d	71.1	(8.9)	78.7	(12.9)	-7.54	(-13.21, -1.87)	**0.01**	-4.50	(-8.09, -0.91)	**0.02**
Carbohydrates										
Carbohydrate, g/d	173.3	(25.0)	186.3	(34.1)	-13.01	(-28.43, 2.40)	0.1	-14.92	(-26.01, -3.83)	**0.01**
Carbohydrate, g/kg/d	9.7	(1.5)	10.4	(2.1)	-0.74	(-1.68, 0.20)	0.1	-0.55	(-1.18, 0.29)	0.1
Carbohydrate, %E/d	55.1	(3.6)	54.0	(4.1)	1.02	(-1.00, 3.04)	0.3	0.57	(-1.32, 2.46)	0.6
Protein										
Protein, g/d	50.2	(9.5)	44.9	(8.7)	5.30	(0.44, 10.17)	**0.03**	5.01	(1.28, 8.73)	**0.01**
Protein, g/kg/d	2.8	(0.4)	2.5	(0.5)	0.28	(0.04, 0.52)	**0.02**	0.33	(0.11, 0.54)	**0.004**
Protein, %E/d	17.0	(2.0)	13.9	(1.9)	3.05	(2.00, 4.10)	**<0.001**	3.00	(1.99, 3.99)	**<0.001**
Fat										
Fat, g/d	46.9	(7.4)	59.3	(13.4)	-12.4	(-17.9, -7.0)	**<0.001**	-10.50	(-14.14, -6.85)	**<0.001**
Fat, g/kg/d	2.6	(0.4)	3.3	(0.6)	-0.66	(-0.94, -0.38)	**<0.001**	-0.52	(-0.74, -0.30)	**<0.001**
Fat, %E/d	27.9	(5.6)	32.0	(4.3)	-4.07	(-6.13, -2.01)	**<0.001**	-3.58	(-5.52, -1.63)	**<0.001**

Data are mean (SD); Significance $p<0.05$; Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d per kilogram of body weight per day
[1] Comparison of randomised groups using independent t-test
[2] Linear regression adjusted for age, sex and corresponding baseline variable

Table 9-9 Comparison of randomised groups for diet scores at 6-month follow-up

	Intervention n=35		Control n=24		Difference (unadjusted) [1]			Difference (adjusted) [2]		
					Mean (95% CI)		p	Mean (95% CI)		p
Vegetable score [3]	0.6	(0.3)	0.1	(0.2)	0.52	(0.39, 0.66)	**<0.001**	0.51	(0.38, 0.64)	**<0.001**
Fruit score [3]	0.7	(0.3)	0.1	(0.2)	0.51	(0.41, 0.63)	**<0.001**	0.51	(0.38, 0.64)	**<0.001**
Dairy score [3]	0.2	(0.1)	0.1	(0.1)	0.06	(0.01, 0.11)	**0.02**	0.07	(0.02, 0.12)	**0.01**
Bread score [3]	0.4	(0.3)	0.0 1	(0.1)	0.39	(0.25, 0.53)	**<0.001**	0.39	(0.24, 0.53)	**<0.001**
Rice, pasta, legumes score [3]	0.9	(0.2)	0.8	(0.2)	0.08	(-0.04, 0.21)	0.2	0.08	(-0.05, 0.20)	0.2
Meat, egg, poultry score [3]	1.0	(0.2)	0.9	(0.3)	0.09	(-0.03, 0.21)	0.1	0.13	(0.12, 0.25)	**0.03**
Fish score [3]	0.6	(0.5)	0.2	(0.4)	0.40	(0.17, 0.62)	**0.001**	0.41	(0.18, 0.65)	**0.001**
Fats and oils score [3]	0.02	(0.1)	0.0 2	(0.1)	-0.00	(-0.04, 0.04)	0.1	0.003	(-0.04, 0.05)	0.9
Sugar sweetened beverages score [4]	0.5	(0.3)	0.1	(0.2)	0.32	(0.14, 0.54)	**<0.001**	0.31	(0.15, 0.46)	**<0.001**
Candy score [4]	0.5	(0.5)	0.1	(0.3)	0.34	(0.13, 0.56)	**0.002**	0.36	(0.14, 0.58)	**0.002**
Total diet score [5]	5.3	(1.4)	2.3	(0.8)	2.72	(2.07, 3.37)	**<0.001**	2.69	(2.03, 3.36)	**<0.001**

Data are mean (SD) unless indicated. Significance $p<0.05$
[1] Comparison of randomised groups using independent t-test
[2] Linear regression adjusted for age, sex and corresponding baseline variable
[3] scores calculated as a proportion of recommended intake, range between 0 and 1, where 1 denotes greater consumption
[4] scores calculated as a proportion of recommended intake, range between 0 and 1, where 0 denotes consumption greater than recommended amount.
[5] Sum of individual diet score components, range between 0 and 10, where 10 denotes a healthier and higher diet quality diet

Table 9-10 Anthropometric and cardiovascular change within subjects at 6 months from baseline

	Intervention n=75			Control n=71			Comparison between randomised groups (0 – 6 months)[2]		
	Mean difference (95% CI)		p[1]	Mean difference (95% CI))		p[1]	Mean difference (95%CI)		p
Weight, kg	0.94	(0.72, 1.17)	**<0.001**	1.33	(1.16, 1.51)	**<0.001**	-0.39	(-0.67, -0.10)	**0.01**
Weight z score	-0.06	(-0.15, 0.03)	0.2	0.11	(0.03, 0.18)	**0.01**	-0.16	(-0.28, -0.05)	**0.01**
Height, cm	2.21	(1.97, 2.45)	**<0.001**	2.21	(1.99, 2.44)	**<0.001**	-0.002	(-0.33, 0.33)	1.0
Height z score	-0.24	(-0.29, -0.19)	**<0.001**	-0.22	(-0.34, -0.10)	**<0.001**	-0.02	(-0.14, 0.10)	0.7
BMI, kg/m^2	0.17	(-0.03, 0.37)	0.1	0.53	(0.38, 0.68)	**<0.001**	-0.36	(-0.61, -0.11)	**0.01**
BMI z score	0.14	(-0.01, 0.28)	0.1	0.40	(0.29, 0.51)	**<0.001**	-0.26	(-0.43, -0.09)	**0.004**
Waist circumference, cm	0.38	(-0.28, 1.04)	0.2	0.48	(-0.30, 1.27)	0.2	-0.10	(-1.11, 0.92)	0.9
Sum of skinfolds, mm [3, 4]	0.24	(-1.18, 1.65)	0.7	0.18	(-0.60, 0.96)	0.6	0.06	(-1.58, 1.69)	0.9
Systolic blood pressure, mmHg [4]	4.63	(2.75, 6.51)	**<0.001**	2.24	(-0.44, 4.92)	0.1	2.39	(-0.81, 5.60)	0.1
Diastolic blood pressure, mmHg [4]	2.09	(0.3, 3.89)	**0.02**	0.64	(-1.80, 3.08)	0.6	1.44	(-1.53, 4.42)	0.3
Resting heart rate, beats/min [4]	-2.19	(-4.88, 0.68)	0.1	-3.06	(-6.35, 0.22)	0.1	0.96	(-3.29, 5.21)	0.7

Data are mean (SD); BMI, body mass index; significance p<0.05
[1] Comparison of randomised groups using paired t-test
[2] Comparison of randomised groups using independent t-test
[3] Log_e transformed, geometric mean (coefficient of variation)
[4] <3% missing data

Table 9-11 Behavioural measures change within subjects at 6 months from baseline

	Intervention n=75			Control n=71			Comparison between randomised groups (0 – 6 months) [2]		
	Mean difference (95% CI)		p	Mean difference (95% CI)		p	Mean difference (95%CI)		p
General behaviour									
Mood score[3]	1.67	(0.68, 2.65)	**0.001**	0.87	(-0.15, 1.89)	0.1	0.79	(-0.61, 2.20)	0.3
Sleep duration, hrs/day	0.03	(-0.26, 0.13)	0.9	-0.32	(-0.58, -0.07)	**0.01**	0.36	(-0.03, 0.74)	0.1
Diet related behaviour									
Eating behaviour score[3]	1.48	(0.27, 2.69)	**0.02**	-0.55	(-1.83, 0.73)	0.4	2.03	(0.28, 3.78)	**0.02**
Appetite score[4]	0.16	(-1.06, 1.38)	0.8	-0.62	(-1.72, 0.48)	0.3	0.78	(-0.86, 2.42)	0.3
Enjoyment of food score[3]	8.84	(6.62, 11.06)	**<0.001**	-0.52	(-2.69, 1.64)	0.6	9.36	(6.28, 12.4)	**<0.001**
Helpings of fruit and vegetables per day	0.80	(0.51, 1.09)	**<0.001**	-0.19	(-0.42, 0.04)	0.1	0.99	(0.62, 1.36)	**<0.001**
Activity related behaviour									
Active behaviour score[3]	0.76	(-0.28, 1.80)	0.2	-0.84	(-2.14, 0.45)	0.2	1.61	(-0.04, 3.25)	0.1
Sedentary activity, hrs/wk	-1.68	(-2.89, 0.47)	**0.01**	1.37	(0.17, 2.56)	**0.03**	-3.05	(-4.73, -1.36)	**<0.001**
Physical activity, hrs/wk	3.36	(2.11, 4.61)	**<0.001**	-0.39	(-1.44, 0.65)	0.5	3.75	(2.13, 5.38)	**<0.001**

Data are mean (SD); Significance $p<0.05$
[1] Comparison of randomised groups using paired t-test
[2] Comparison of randomised groups using independent t-test
[3] Sum of score from 10 point Likert scale: higher score denotes a positive change except for appetite score[4]
Mood score ranges between 1-30 (maximum score: child is happy, does not get upset easily, is communicative)
Active behaviour score ranges between 1-70 (maximum score: child is active, energetic, and plays a lot)
Eating behaviour score ranges between 1-40 (maximum score: child is easy, calm, attentive, slow during meals)
Appetite score ranges between 1-70 (maximum score: child has a big appetite, not full at end of meal, always asking for food (scores reversed)
Enjoyment of food score ranges between 1-50 (maximum score: child enjoys tasting new foods, a variety of foods, enjoys fruits and vegetables)

Table 9-12 Energy and macronutrient intake change within subjects at 6 months from baseline

	Intervention n=35			Control n=24			Comparison between randomised groups (0 – 6 months) [2]		
	Mean difference (95% CI)		p[1]	Mean difference (95% CI)		p[1]	Mean difference (95% CI)		p
Energy									
Energy, kcal/d	-54.05	(-82.46, -25.63)	**<0.001**	61.07	(18.93, 103.21)	**0.01**	-115.12	(-162.88, -67.35)	**<0.001**
Energy, kcal/kg/d	-7.15	(-9.12, -5.19)	**<0.001**	-3.18	(-6.45, 0.08)	0.06	-3.97	(-7.47, -0.46)	**0.03**
Carbohydrates									
Carbohydrate, g/d	0.86	(-5.99, 7.73)	0.8	14.53	(3.80, 25.27)	**0.01**	-13.66	(-25.52, -1.81)	**0.03**
Carbohydrate, g/kg/d	-0.48	(-0.89, -0.06)	**0.03**	-0.06	(-0.76, 0.65)	0.9	-0.42	(-1.17, 0.33)	0.3
Carbohydrate, %E/d	2.00	(0.48, 3.49)	**0.01**	1.63	(-0.48, -3.75)	0.1	0.35	(-2.11, 2.81)	0.8
Protein									
Protein, g/d	4.02	(1.38, 6.66)	**0.004**	-1.52	(-4.66, 1.61)	0.3	5.55	(1.53, 9.57)	**0.01**
Protein, g/kg/d	0.07	(-0.08, 0.22)	0.4	-0.33	(-0.52, -0.13)	**0.002**	0.39	(0.15, 0.63)	**0.002**
Protein, %E/d	1.80	(0.93, 2.67)	**<0.001**	-1.26	(-2.20, -0.34)	**0.01**	3.07	(1.80, 4.34)	**<0.001**
Fat									
Fat, g/d	-8.19	(-10.9, -5.41)	**<0.001**	1.54	(-2.42, 5.50)	0.4	-9.73	(-14.3, -5.15)	**<0.001**
Fat, g/kg/d	-0.63	(-0.79, -0.47)	**<0.001**	-0.18	(-0.42, 0.06)	0.1	-0.45	(-0.72, -0.18)	**0.002**
Fat, %E/d	-3.78	(-5.26, -2.31)	**<0.001**	-0.37	(-2.66, 1.93)	0.7	-3.42	(-5.96, -0.87)	**0.01**

Data are mean (SD); Significance $p<0.05$; Kcal, kilocalories; g/d, grams per day, %E percentage of daily energy intake; kg/d Per kilogram of body weight per day
[1] Comparison of randomised groups using paired t-test
[2] Comparison of randomised groups using independent t-test

Table 9-13 Diet scores change within subjects at 6 months from baseline

	Intervention n=35			Control n=24			Comparison between randomised groups (0 – 6 months) [2]		
	Mean difference (95% CI)		p [1]	Mean difference (95% CI)		p [1]	Mean difference (95% CI)		p
Vegetable score[3]	0.42	(0.27, 0.56)	**<0.001**	-0.07	(-0.16, 0.02)	0.1	0.48	(0.29, 0.68)	**<0.001**
Fruit score[3]	0.42	(0.32, 0.52)	**<0.001**	-0.05	(-0.15, 0.04)	0.3	0.47	(0.32, 0.62)	**<0.001**
Dairy score[3]	0.03	(-0.02, 0.08)	0.3	-0.07	(-0.14, 0.00)	0.1	0.10	(0.01, 0.18)	**0.02**
Bread score[3]	0.17	(0.02, 0.32)	**0.03**	-0.27	(-0.42, -0.11)	**0.002**	0.44	(0.22, 0.66)	**<0.001**
Rice, pasta, legumes score[3]	0.08	(-0.03, 0.19)	0.2	-0.04	(-0.18, 0.10)	0.6	0.12	(-0.06, 0.29)	0.2
Meat, egg, poultry score[3]	0.13	(0.05, 0.21)	0.3	-0.09	(-0.23, 0.04)	0.2	0.22	(0.07, 0.37)	**0.004**
Fish score[3]	0.16	(-0.06, 0.38)	**0.003**	-0.06	(-0.30, 0.19)	0.6	0.22	(-0.12, 0.55)	0.2
Fats and oils score[3]	-0.05	(-0.09, -0.00)	0.2	-0.08	(-0.18, 0.02)	0.1	0.03	(-0.07, 0.13)	0.5
Sugar sweetened beverages score[4]	0.35	(0.22, 0.49)	**<0.001**	0.05	(-0.07, 0.17)	0.4	0.30	(0.12, 0.49)	**0.002**
Candy score[4]	0.49	(0.33, 0.64)	**<0.001**	0.14	(0.01, 0.27)	**0.04**	0.34	(0.13, 0.56)	**0.002**
Total diet score[5]	2.20	(1.62, 2.77)	**<0.001**	-0.52	(-0.99, -0.07)	**0.03**	2.73	(1.95, 3.50)	**<0.001**

Data are mean (SD); significance p<0.05
[1] Comparison of randomised groups using paired t-test
[2] Comparison of randomised groups using independent t-test
[3] Scores calculated as a proportion of recommended intake, range between 0 and 1, where 1 denotes greater consumption
[4] Scores calculated as a proportion of recommended intake, range between 0 and 1, where 0 denotes consumption greater than recommended amount.
[5] Sum of individual diet score components, range between 0 and 10, where 10 denotes a healthier and higher diet quality diet

Table 9-14 Parental observations on child's behaviour and parents' feedback on the usefulness of the intervention

	Score (n=75) Mean	(SD)
Child's behaviour [1]		
Eats more fruit	6.2	(1.3)
Eats more types of fruit	6.1	(1.3)
Enjoys fruit	6.3	(1.2)
Eats more vegetables	5.2	(1.0)
Eats more types of vegetables	5.1	(0.8)
Enjoys vegetables	5.1	(1.2)
Eats fewer salty snacks	5.6	(1.4)
Drinks fewer sugary and fizzy drinks	6.2	(2.1)
Consumes fewer salty snacks	5.6	(1.4)
Asks for more fruit and vegetables	5.4	(1.0)
I can manage my child's behaviour better	6.3	(1.4)
I cope better with fussy eating at mealtimes	6.8	(1.5)
Mealtimes are more structured	6.8	(1.3)
Parental feedback [1]		
I can understand portion sizes better	7.0	(1.5)
I am able to understand food labels better	4.8	(1.3)
I feel my child has benefited from the study	6.9	(1.3)
I benefited from the study	6.0	(1.1)
Overall usefulness of Eat Right Emirates tool [2]	7.2	(1.5)

[1] High score denotes a strong agreement.
[2] High score indicates the ERE tool was very useful

Table 9-15 Parental verbal feedback on the Eat Right Emirates tool

Topic	Parental feedback - Quotes
Usefulness and benefits	'Offering different foods, my child accepts more' 'Organising mealtime was helpful' 'Helped me make small changes, information was easy' 'I stopped giving sweets to make him eat more' 'Managed mealtimes was useful' 'Very useful, I focused on giving my child fruits and vegetables, and I also ate more' 'Helped me make 'healthy' changes' 'Eats better with his siblings' 'Eats more fruit'
Portion size	'Portion size samples was easy and helpful' 'Following portion size information was useful' 'Portion sizes were useful' 'Foods to offer, snack and mealtime with portion size' 'Very informative, portion size information was helpful'
More information needed	'Very useful, but I wanted more information' 'More portion size information wanted' 'Want more information because my child is fussy' 'Information is limited, need more information on different food and recipes for children' 'I need more information like this to know what to feed my child' 'I benefited from the information, but I would like more' 'I found it helpful and clear, I wanted more information on different food options' 'I want more information about food labels'
22 out of 75 mothers provided verbal feedback	

Chapter 10 Overall Discussion and Conclusions

Knowledge is a treasure, but practice is the key to it- Arabian Proverb

10.1 Introduction

The overall aims of this thesis were to identify risk factors for preschool overweight and obesity in the United Arab Emirates, and investigate the effectiveness of a simple, healthy lifestyle intervention tool 'Eat Right Emirates' in reducing obesity risk.

In order to achieve this, I completed three studies to address these aims and potentially address gaps in the literature. Therefore, this chapter is subdivided into three sections to present and discuss the findings of each study, which collectively provide a better understanding of what factors are responsible for the rising prevalence of preschool obesity and how a simple leaflet-based intervention could be used to promote a healthy lifestyle and prevent preschool obesity in the UAE.

10.2 Study 1: Risk factors of preschool obesity in the UAE

The present study identified early life risk factors associated with overweight and/or obesity in preschool Emirati children, including duration of breastfeeding, timing of complementary feeding, birth weight, and mother's age. These findings are discussed below in the context of previous research.

10.2.1 Breastfeeding

Accumulating evidence from systematic reviews and meta-analyses suggests that breastfeeding is protective against childhood obesity (Arenz et al., 2004; Harder et al., 2005; Owen et al., 2005a; Weng et al., 2012; Yan et al., 2014; Horta et al., 2015; Patro-Golab et al., 2016). A recent meta-analysis reviewing 105 studies concluded that breastfeeding is associated with a 26% reduced risk of obesity in childhood and adulthood (Horta et al., 2015).

However, the observational nature of these studies cannot confer causality or exclude the influence of residual confounding. Furthermore, evidence from a

Belarusian randomised controlled trial found that a breastfeeding promotion intervention did not influence obesity risk (Martin et al., 2013). Therefore, the association between breastfeeding and later obesity remains inconsistent and is a highly debated topic (Woo Baidal et al., 2016) (see, Table 2-1).

Nevertheless, similar to previous observational studies linking longer duration of breastfeeding with lower BMI z-score and lower risk of childhood overweight and/or obesity (Hawkins et al., 2009; Chivers et al., 2010; Bammann et al., 2014; Oddy et al., 2014; Wang et al., 2017), the current study found that each month of any breastfeeding was associated with a 0.02 reduction in BMI z-score (p=0.05), and a 26% reduction in the risk of overweight/obesity (p=0.01), after adjusting for confounders (Tables 7-10 and 7-11). Breastfeeding for more than 6 months (vs. never breastfeeding) was also found to be associated with a lower risk of overweight/obesity (97% reduction; p=0.03). Although this association was attenuated after adjusting for confounding factors, a similar finding was also observed in a recent US study (Wang et al., 2017), which, when comparing children breastfed to 6 months, to those never breastfed, only found a significant association in unadjusted analyses (OR=0.58, 95% CI: 0.36 to 0.94) (Wang et al., 2017). Findings of this current study are also consistent with a review by Yan et al. (2014), in which analysis of 17 studies found a 21% lower obesity risk in children breastfed for more than 7 months (AOR=0.79, 95% CI: 0.70, 0.88). Therefore, in agreement with earlier studies (Arenz et al., 2004; Harder et al., 2005; Yan et al., 2014), the current research suggests a dose-response association between a longer duration of breastfeeding and lower obesity risk in the UAE.

No previous study has investigated the association between breastfeeding and preschool obesity in the UAE. However, many researchers have reported that infant feeding practices are suboptimal in the UAE and neighbouring Arab Gulf countries. In this current study, breastfeeding rates were high (97% of children were ever breastfed, and only 3% were exclusively formula fed). These findings are similar to those reported by the UAE Family Health Survey (97% breastfed)(Fikri and Farid, 2000), and a more recent study in Abu Dhabi, UAE, which reported 95% of Emirati women breastfed from birth (Gardner et al., 2015).

Therefore, breastfeeding appears to be protective against the early risk of obesity in the UAE, even in a population with a high rate of breastfeeding.

However, exclusive breastfeeding in the present study was low. Although by 2025 the WHO aims to achieve a 50% universal exclusive breastfeeding rate (World Health Organisation, 2014), exclusive breastfeeding in the UAE was only 23% at 6 months old. Similar to these findings, Radwan (2013) reported that across maternal and child health clinics in Al Ain, Dubai and Abu Dhabi, 25% of mothers (n= 593) exclusively breastfed at 6 months. However, Gardner et al. (2015) more recently reported considerably lower rates in Abu Dhabi (n=125), with only 5% of mothers exclusively breastfeeding at 3 months and beyond. While the current study did not qualitatively investigate reasons for the low rate of exclusive breastfeeding, previous studies have suggested that early supplementation with formula milk is considered a norm in the UAE, as mothers believe breast milk alone is insufficient. The use of herbal remedies is also common. Radwan (2013) reported that 30% of children were given non-milk fluids (e.g. aniseed drink, grippe water and tea) before 3 months. Likewise, Gardner et al. (2015) reported that by 3 months, 68% of mothers introduced tea, 26% introduced milk (cow/camel) and sweetened water (sugar mixed with water), 27% were given dates, and 15% were given fruit juice.

Interestingly, although global initiatives have focused their efforts on promoting exclusive breastfeeding for maternal and child health benefits, evidence for an association between exclusive breastfeeding, as opposed to any breastfeeding, and childhood obesity is inconsistent (Patro-Golab et al., 2016; Woo Baidal et al., 2016). For instance, in the current study, exclusivity of breastfeeding was found to be associated with lower overweight/obesity risk (adjusted OR=0.59, 95% CI: 0.42 to 0.84), but not with BMI z-score. Although some studies have found an inverse association between exclusive breastfeeding and obesity risk (Bammann et al., 2014; Oddy et al., 2014), there is currently no consensus that exclusive breastfeeding, irrespective of its duration, is protective against obesity or high BMI in later childhood (Owen et al., 2005a; Hörnell et al., 2013a; Patro-Golab et al., 2016). Discrepancies cited in the literature between exclusive breastfeeding and later childhood overweight or BMI could be due to differences in definitions of breastfeeding exclusivity, or the influence of other unmeasured behavioural factors in previous studies. However, as the present study was relatively underpowered, it was not possible to evaluate categorical associations (i.e. less than 4 or 6 months), or provide robust evidence for this association.

As reviewed in section 2.3.1.2, several biological and behavioural mechanisms have been suggested to explain the association between duration of breastfeeding and lower risk of later childhood obesity. The lower protein content of breast milk compared to formula milk has been suggested to help prevent fast growth during infancy (Singhal and Lucas, 2004) and therefore reduce the risk of obesity in later life. In addition, the ability of breastfed infants to self-regulate their intake in response to internal satiety cues may also be important (Gale et al., 2012; Oddy et al., 2014; Zheng et al., 2014). Finally, because breast milk provides optimal nutrition for infants up to the age of 6 months (Gartner et al., 2005; World Health Organisation, 2014) delays in timing of introduction of complementary foods may also help reduce the risk of obesity (Yan et al., 2014; Horta et al., 2015; Wang et al., 2016).

10.2.2 Complementary feeding

The present study found strong evidence that later introduction of complementary foods is associated with a lower BMI z-score and reduced overweight/obesity risk in Emirati preschool children. Later introduction of complementary foods was associated with a -0.38 ($p<0.001$) lower BMI z-score, and introduction of solids after 4 months old (compared to before 4 months) was associated with 97% lower risk of overweight/obesity ($p<0.001$) independent of confounders including breastfeeding duration (see, Table 7-11).

These findings are consistent with previous studies linking early introduction of complementary foods and later childhood overweight or obesity (Brophy et al., 2009; Hawkins et al., 2009; Seach et al., 2010; Durmus et al., 2011; Wen et al., 2014). For example, Brophy et al. (2009) found that introducing solids before 3 months increased the risk of overweight/obesity at 5 years of age (adjusted OR= 1.2; 95% CI: 1.02 to 1.5). Similarly, findings from the UK Millennium Cohort (n=13,188) found that early introduction of complementary foods before 4 months was associated with overweight in 3-year-old children, even after adjusting for confounding factors (adjusted OR=1.12; 95% CI 1.02 to 1.23)(Hawkins et al., 2009). Furthermore, the most recent meta-analysis (Wang et al., 2016) found that the introduction of complementary foods before four months of age, compared with 4 to 6 months was associated with an increased risk of overweight and obesity in 5 out of 8 studies (pooled Relative Risk (RR)= 1.18; 95% CI: 1.06 to 1.31).

However, associations between the timing of complementary feeding and obesity have not been observed in all studies (Burdette et al., 2006; Neutzling et al., 2009; Moorcroft et al., 2011). In a narrative review of 26 studies, most (n=17) found no association (Daniels et al., 2015). This review included the only RCT (Mehta et al., 1998), and five large studies of high quality (Reilly et al., 2005; Griffiths et al., 2009; Griffiths et al., 2010; van Rossem et al., 2013), but only one study reported a strong positive association between the introduction of solids before 4 months and later obesity in formula fed (AOR= 6.2; 95% CI: 2.3 to 16.3), but not breastfed children (Huh et al., 2011).

Although the heterogeneity between studies, the observational nature of investigations, and the errors related to retrospective recall of infant feeding data need to be taken into consideration when interpreting findings, the current research in the UAE is consistent with most of the literature in Western countries (Weng et al., 2012; Pearce et al., 2013; Qasem et al., 2015; Wang et al., 2016), and suggests that the early introduction of solids, prior to 4 months, could be one risk factor for later childhood overweight and obesity.

The mechanism behind early introduction of complementary foods and higher risk of overweight or obesity remains unclear (see section 2.3.1.5)(Woo Baidal et al., 2016). Potential explanations include higher energy (Ong et al., 2006) and/or protein intake (Günther et al., 2007) with complementary feeding which could increase insulin-like growth factor-1 concentrations, and predict faster weight gain and later adiposity in childhood (Owen et al., 2005a). Another potential mechanism, as discussed above, is that early introduction of complementary foods may displace breastfeeding (Holmes et al., 2011), and therefore reduce the protectiveness of breastfeeding against childhood obesity (Yan et al., 2014; Grube et al., 2015).

The association between infant nutrition and obesity may be particularly important in the UAE, where there is poor adherence to nutrition recommendations (Radwan, 2013; Salem, 2014; Gardner, 2015). Several reasons have been suggested to explain why mothers choose to introduce solids. These include the perception that breast milk is insufficient, the lack of family support, or, in some cases, mothers may opt to use traditional remedies to soothe the infant, such as diluting dates in water or formula milk. Therefore, because cultural norms may impose inappropriate infant feeding practices and increase the risk of childhood obesity in the UAE, this area of research needs further investigation.

10.2.3 Birth weight

Although this study demonstrated a positive association between birth weight and BMI z-score in preschool children, the significance of this association was not sustained after adjusting for confounding factors. This could be because of the small sample size, or low prevalence of obesity in the present study population, making it difficult to identify associations between birth weight categories and childhood obesity.

The relationship between birth weight and childhood obesity has been extensively investigated (Reilly et al., 2005; Hawkins et al., 2009; Rooney et al., 2011) (see, Table 2-1). In a recent systematic review, Woo Baidal et al. (2016) reported that 24 out of 28 studies consistently found a strong positive association between birth weight and later childhood obesity in both developed and developing countries. Li et al. (2014) found that a high birth weight (4kg -4.5kg) had a 2.8 fold risk of obesity at 3 years of age, when compared with children born with a birth weight between 2.5 and 2.9kg in China (Li et al., 2014). Similarly, a large national study in Kuwait found that birth weight was significantly associated with the weight status of preschool children (Al-Qaoud and Prakash, 2009). In contrast, other studies found no link between birth weight and later obesity (Wells et al., 2005; Birbilis et al., 2013), and suggest that a higher birth weight could be related to an increase in lean mass, but not fat mass (Singhal et al., 2003; Wells et al., 2005). Therefore, as mechanisms linking high birth weight and higher risk of childhood overweight and obesity are still unclear, larger studies are needed to adequately investigate this association in the UAE.

10.2.4 Maternal age

In the present study, maternal age was associated with lower BMI z score after adjusting for confounders. To my knowledge this has not been reported previously in the UAE. The finding could have occurred by chance, or may have been influenced by unmeasured confounding socio-demographic factors. For example, older mothers in this study may have had greater nutrition knowledge and experience of raising and feeding children, compared to younger mothers, who may be more influenced by other family members (e.g. grandmothers) to overfeed their child.

In comparison to other extensively investigated risk factors (Monasta et al., 2010), the impact of maternal age on childhood obesity has not been clearly established in the literature (Reilly et al., 2005; Wang and Lobstein, 2006; Blair et al., 2007). This could be because maternal age is often confounded by other social factors (Monasta et al., 2010; Mills and Lavender, 2011).

There is currently no clear explanation as to why children born to older mothers have a lower risk of obesity (Heppe et al., 2012; Savage et al., 2013). Savage et al. (2013) found an inverse association between maternal age at childbirth and child BMI z-score, Children born to mothers over 30 years of age may also have a lower metabolic risk (e.g. lower insulin growth factor concentrations) compared to children born to younger mothers (Facchini et al., 2001). Potential mechanisms for this association include a combination of maternal age-related changes in prenatal and post-natal environment, including epigenetic changes in children born to older mothers (Broekmans et al., 2009; Grondahl et al., 2010) or maternal hormonal changes, which could influence the *in utero* environment and post-natal growth (Wang and vom Saal, 2000).

10.2.5 Potential risk factors not supported by data from the current study

Several risk factors for preschool overweight and obesity described in the literature were not found in the current study. These include maternal BMI, maternal educational level, social class, physical activity level, time spent in sedentary behaviours, and sleep duration (Reilly et al., 2005; Griffiths et al., 2010; Taveras et al., 2010).

Evidence linking maternal BMI and childhood overweight or obesity is strong and consistent in the literature (Whitaker, 2004; Wardle, 2005; Dubois and Girard, 2006). In Kuwait, Al Qaoud et al. (2010) found that maternal obesity was associated with a 2.6-fold increase in the risk of preschool obesity. However, in this study, although a positive trend between maternal BMI and preschool BMI z-score was observed, this was not significant following the adjustment for confounders. This finding could have been confounded by the high prevalence of overweight/obesity in mothers in this study (64%, BMI >25 kg/m^2), or mothers may have underreported their body weight, and therefore biased these findings.

The association between socio-economic status and childhood obesity is found to vary between high-income and developing countries (Wang et al., 2006). While the risk of childhood obesity is found to be highest in low socioeconomic groups living in high-income Western countries, obesity seems to be a problem of the rich (high socio-economic groups) in developing low/middle income countries (Stamatakis et al., 2010; Dinsa et al., 2012; Wang and Lim, 2012). However, little is known about how this relationship operates in middle-income countries like the UAE, which are in the nutrition transition (Mirmiran et al., 2010; Gupta et al., 2012).

In this present study, a positive trend was observed between indicators of high socio-economic status (mothers' high levels of education and fathers' non-manual occupations) and children's BMI z-score, similar to trends observed in other developing countries (Mushtaq et al., 2011; Gupta et al., 2012; Nasreddine et al., 2017). This association in countries in transition could be explained by greater access to energy-dense foods, electronic devices (e.g. iPads, TV sets) and fast-food restaurants, which may in turn lead to a positive energy balance

(Mirmiran et al., 2010). Also, it could possibly be due to the few mothers of low socio-economic status included in the current study.

Some observational studies have found an association between low levels of physical activity and increased obesity risk in children (Dennison et al., 2002; Monasta et al., 2010; te Velde et al., 2012; Wen et al., 2014). However, this relationship is inconsistent in the literature (Cliff et al., 2016; van Ekris et al., 2016). The current study found that 86% of children failed to meet the recommended three hours of physical activity, and 60% spent more than one hour in sedentary activities (e.g. TV, video games etc.). However, neither physical activity nor time spent in sedentary behaviours was associated with overweight/obesity or BMI z-score.

The absence of an association between physical activity and preschool overweight/obesity or BMI z-score could be due to the subjective nature of measuring physical activity using parent-reported questionnaires. However, studies that have used objective measures (e.g. accelerometers) have also not found consistent evidence (Sallis and Saelens, 2000; Reilly et al., 2006). In the Arabian Gulf, studies in adults have reported associations between low physical activity levels and obesity, possibly because of the rapid industrialisation following the discovery of oil (Musaiger and Al-Hazzaa, 2012; ALNohair, 2014). Thus, further investigation using objective measures of physical activity in preschool children in the UAE is warranted.

Shorter sleep duration has been suggested to increase obesity risk in preschool children (Cappuccio et al., 2008; Chen et al., 2008; Bell and Zimmerman, 2010), through reduced physical activity due to tiredness (Bell et al., 2010), increased energy intake (McDonald et al., 2014), or by influencing hypothalamic mechanisms that regulate body weight (e.g. leptin and ghrelin) (Spiegel et al., 2004). Previous studies have found inverse associations between sleep and obesity risk in school-aged children (11–18 year olds) in Saudi Arabia (Bawazeer et al., 2009) and Qatar (Bener et al., 2011), However, the present study did not confirm this. This could be due to errors related to parent-reported questionnaires used to measure sleep duration. Although previous studies have observed moderate correlations between parent-reported questionnaires and more subjective measures of sleep duration (e.g. actigraphy, sleep logs, and diaries), the validity of these questionnaires is not well established in children aged 3–10 years (Sekine et al., 2002; Chen et al., 2008), and therefore findings are subject to measurement error.

10.2.6 Prevalence of Overweight and Obesity

Although estimating the prevalence of overweight and/or obesity was not a primary aim of the current study, 11% of preschool Emirati children were classified as overweight/obese using the WHO 2006 growth standard and WHO 2007 growth reference (World Health Organisation, 2006; de Onis et al., 2010). This is comparable to a recent study in Ras Al Khaimah, UAE. Al Blooshi et al. (2016) found that, among 3- to 6-year-old children (n=6,731), the prevalence of overweight, obesity and extreme obesity was 14% using WHO (BMI for age >85th percentile), 12% using IOTF (BMI > 25kg/m^2) and 14% using CDC (BMI for age > 85th percentile). Therefore, the current study confirms the findings of the systematic review in Chapter 1, which suggests that the prevalence of overweight and obesity among preschool children in the UAE is high. However, unlike Al Blooshi et al. (2016), who reported a higher prevalence of overweight, obesity and extreme obesity in girls compared to boys, the present study found no gender differences. Due to constraints of the current PhD, it was not possible to investigate regional differences in obesity (e.g. urban v rural).

It is important to note that, due to different sampling methods, sample sizes, age ranges of included children, and definitions used to classify overweight and obesity, it is difficult to compare previous studies. In particular, the prevalence of overweight and obesity varies according to the growth references and cut offs used (e.g. CDC, WHO, IOTF) (see section1.4.1) (Flegal et al., 2001). Although in-depth comparative analysis of definitions of overweight and obesity using different references is beyond the scope of this thesis, it is interesting to note that 11% of preschool children in the current population were above the IOTF cut offs for overweight and obesity. This showed moderate level of agreement with prevalence of overweight and obesity classified according to WHO 2006 growth standard and WHO 2007 growth references (Cohen's Kappa: 0.7; $p<0.001$). However, the agreement between WHO and IOTF observed in the present study is unusual as IOTF references and cut-offs are consistently reported to underestimate the prevalence of overweight and obesity (Reilly, 2002; Al-Sendi et al., 2003; AlBlooshi et al., 2016). This emphasises the importance of studies using a standard reference to facilitate comparisons.

There is currently no gold standard to define obesity in childhood. This is particularly problematic for countries such as the UAE and Arabian Gulf countries, where the absence of local age and sex specific growth references for children necessitates the use of reference data from other countries. The IOTF and WHO references have been recommended for international comparisons (Cole et al., 2000; de Onis et al., 2010). Therefore, in the current study, because the IOTF reference data did not include Middle Eastern countries, the WHO 2006 growth standards and WHO 2007 growth references were chosen, since the WHO 2006 growth standard was based on data collection from six countries (including Oman, which neighbours the UAE, and shares similar cultural and societal factors), and make international comparisons easier (see section 6.8.12).

10.2.7 Mothers' perceptions of children's weight status

An interesting finding of the current study was that a substantial proportion (24%) of mothers misclassified their child's weight status, which supports findings of previous studies (Hashemi, 2009; Rietmeijer - Mentink et al., 2013; Lundahl et al., 2014). In the UAE and neighbouring countries, parental misclassification or misperception is unsurprisingly common. Al Junaibi et al. (2013) found that 34% of parents in the UAE misclassified their 6- to 19-year-old children's weight status. In the present study, the prevalence of misclassification was slightly lower at 24%, which could be because of the younger age group under study, or mothers in the present study were more attentive and aware. However, in Kuwait, Al Qaoud et al. (2010) reported that 97% of mothers of preschool children underestimated the weight status of their overweight children, which is comparable to the 88% reported this study, where 15 of the 17 overweight/obese children were misclassified as normal weight.

Several societal and cultural factors have been suggested to influence parent's ability to correctly classify their child’s weight status (Chaimovitz et al., 2008; Mathieu et al., 2010). For instance, intercultural variations of what ‘healthy weight’ means have been observed (Musaiger, 1993; Williams et al., 2008; Bayles, 2010), which could influence a parent or mother’s perception of weight status. Since plumpness is considered a sign of affluence in the Middle Eastern region, mothers who misclassified their overweight/obese children may have genuinely perceived their child’s weight as normal, whereas other mothers may have deliberately chosen to underestimate their child’s weight status in order to avoid stigmatisation.

In the Arabian Gulf region, parental perception of a child’s weight status is an area that is often overlooked, despite the high and rising prevalence of childhood obesity (see systematic review in section 1.12) (Farrag et al., 2017). Thus, the present findings highlight a cause for concern, especially because parental recognition of children’s overweight and/or obesity is a key factor in early prevention of obesity.

10.2.8 Strengths

To my knowledge, this is the first study to investigate risk factors of preschool overweight and obesity in the UAE. The main strength of the present study is that several key modifiable and non-modifiable risk factors were collected, including, socio-demographic, parental, developmental and behavioural factors.

The study was able to assess associations between risk factors, BMI z-score and risk of overweight/obesity separately, and adjusted for important parental and child characteristics (age, sex, mother’s BMI, mother’s age, mother’s educational level, father’s BMI and father’s occupation).

Another strength of the study was that height and weight used to calculate BMI z-score were measured objectively by trained researchers, rather than using parent-reported height and weight measures, which have been suggested to introduce bias (Weden et al., 2013). Research assistants were trained to accurately measure height and weight, to ensure standardisation.

10.2.9 Limitations

There are, however, several limitations to the research presented. Despite efforts made to recruit a larger sample from more than one study location, logistical and time restrictions within the PhD time frame may have introduced selection bias and reduced generalisability of study findings to a wider population.

As a result of the small sample, another limitation is that the study population was not representative of the general Emirati population. Therefore, repeating this study in more than one city in the UAE (e.g. rural areas like Hatta, and more cosmopolitan cities like Dubai), and in lower socio-economic groups/lower educational levels would provide valuable insight into risk factors for obesity in socio-demographically diverse populations in the UAE. However, the high proportion of Emirati children (97%) included in the study addressed the thesis objective to investigate risk factors of preschool overweight and obesity in the local Emirati population.

Although the study was adequately powered (Cohen, 1992), the relatively small sample of 150 preschool children limited the number of variables that could be included in the logistic regression analyses. Therefore, findings in this study should be interpreted with caution, as the influence of potential confounding factors on some noted associations was not measured.

There are also limitations associated with using BMI z-score as a measure of obesity, as it does not differentiate between fat mass and fat-free mass, and therefore it cannot measure excess fat. It has also been suggested that BMI z-score is a good indicator of adiposity in fatter children, but among thinner children the differences in BMI z-score could be due to fat-free mass and not fat mass (Freedman and Sherry, 2009). Nevertheless, although using an objective measure of adiposity (e.g. dual x-ray absorptiometry) would have strengthened the research, BMI z-score is widely used to estimate the prevalence of overweight and obesity in preschool children, and has proven to be valid and useful in population-based studies.

In view of the fact that the age of children included in this study ranged from 2 to

6 years of age, and overlapped with two WHO charts (WHO 2006 Growth Standard, and WHO 2007 Growth reference), subjective decisions were made in relation to the growth references and cut-offs used to classify overweight/obesity in this study. Both the WHO 2006 growth standard and WHO 2007 growth references were chosen to calculate BMI z-scores and define cut-offs, similar to a previous study in a population of 3- to 6-year-olds (Xiao et al., 2015). However, the same prevalence of overweight and obesity was observed using the WHO and IOTF references (with moderate agreement). Therefore, it was decided that the WHO 2006 growth standard and WHO 2007 growth reference were the most appropriate for the present study population.

Like most previous research, the cross-sectional nature of the present study was a limitation. While the study was able to assess associations between risk factors and BMI z-score, it does not determine causality. Therefore it is not possible to exclude the influence of unmeasured variables, which may have influenced associations presented in this study. Although the study adjusted for potentially confounding factors known to influence obesity risk in preschool children, it is possible that there are other factors, unique to the Arabian Gulf, which were not measured or included. For instance, domestic helpers are commonly employed in Middle Eastern households, and the influence of this help on childhood obesity risk is unknown. While this study aimed to quantify the time a child spent with a domestic helper or ‘child-minder’, many mothers were reluctant to respond accurately. However, from first-hand experience at the preschool, it is apparent that domestic helpers are very much involved in the lives of children in the UAE. Therefore, future research should address the impact of domestic helpers on the risk of overweight and obesity.

Because of the young age of children, data on socio-demographic, behavioural and dietary characteristics of children was collected from parents, as in other studies. Parent-reported questionnaires could have introduced measurement errors, compared to more objective measures (e.g. accelerometers to measure physical activity). However, although only these measures were feasible within the framework of a PhD, the findings in the present study were consistent with and supported by the literature.

Additionally, the dependence on retrospective maternal recall of infant feeding practices and birth weight, without the use of postnatal records, may have introduced some recall error, particularly when quantifying the period of exclusive breastfeeding. However, the recall period in the current study was relatively short (2-6 years) compared to other studies, which have shown close agreement between longer-term recall and postnatal records (Zive et al., 1992; Li et al., 2005). The use of closed-ended questions may also have limited the assessment of attitudes and knowledge deficits in the study population, which could have influenced a mother's misperception of her child's weight status. Therefore, qualitative research would prove useful in addition to future similar research.

10.3 Study 2: The role of diet in preschool obesity: dietary risk factors

In addition to early life risk factors investigated in Study 1. Based on previous research highlighting that diets of children are suboptimal in the Arabian Gulf region, and that dietary intake of preschool children in the UAE has not been previously explored, as presented in the systematic review in Chapter 2 (see section 2.4.3). Study 2 aimed to use food diaries returned by 59 out of the 150 parents enrolled in the study in order to: (i) assess the energy and macronutrient intake of young children using estimated food records; (ii) compare the e nergy and macronutrient intake of preschool children in the UAE to the UK dietary guidelines; (iii) investigate associations between energy, macronutrient intake and BMI z-score. In addition to analysis of single nutrients, this study identified dietary patterns using two approaches: (i) an *a priori* approach using a previously developed diet quality score (Voortman et al., 2015), and (ii) an *a posteriori* approach using principal component analysis. Associations between dietary patterns and BMI z-score were also investigated.

The current research showed that average energy intake, and the percentage of energy from macronutrients, was broadly in line with the UK dietary guidelines for children matched for age and gender. The mean daily energy intake of children (mean age 4.4 years) in study population was found to be slightly lower than the EAR for children aged 4 years old. However, calculating the percentage of children above or below an EAR matched for their age and gender showed that mean energy intake was 61% higher. In comparison to the 19.7gram per day RNI of protein for children aged between 4 and 6 years in the UK, preschool children in the current study consumed almost 2.5 times the RNI on average (46.3 grams per day). Similarly, the mean daily percentage energy from protein (15%) exceeded recommendations (6%). In light of the strong evidence linking protein intake and childhood obesity (Günther et al., 2007; Pimpin et al., 2016), in particular protein from dairy products compared to other sources of protein (plant- or animal-based), these findings are a cause for concern (Pimpin et al., 2015). However, since the current study did not investigate the proportion of energy from specific foods groups or drinks (e.g. dairy or animal meat products), it is not possible to identify whether the high protein intake observed in the study population was due to excessive consumption of milk and dairy products or other protein-rich foods.

In the UAE, children commonly continue to consume follow-on formula or local equivalents (Radwan, 2013; Gardner et al., 2015). For example, in the present study, more than 48% of children over the age of 2 years were still receiving formula milk. Mothers may continue formula feeding or provide high quantities of cow's milk to ensure that their children are full, or gaining enough weight. Therefore, further qualitative evaluation is needed to better understand the reasons behind the extended use of follow-on formula in the UAE.

The average intake of dietary fibre (4 grams per day) was approximately four times less than the recommended amount (15 grams per day). Dietary fibre is important for the prevention of constipation in children. Also, it is well recognised that children should consume a varied diet high in fibre-rich foods (e.g. fruits, vegetables, whole grain cereals) from early childhood, in order to instil healthy habits and reduce the risk of diseases linked to low fibre diets in later life (e.g. colon cancer). The low intake of fibre observed in this study could be explained by the increased accessibility to processed low-fibre foods (e.g. refined carbohydrates, crisps, cakes) and low intake of fruits and vegetables following the nutrition transition. Therefore, since there are currently no dietary guidelines for preschool children in the UAE, it is important that parents are provided with tailored guidance regarding optimum nutrition and are made aware of the importance of encouraging a well-balanced diet.

10.3.1 Energy and macronutrient intake and obesity

The role of diet in the development of preschool obesity in the UAE is unknown (see section 2.4.3). Therefore, this study investigated the relationship between dietary intake and BMI z-score in preschool Emirati children, and tested the hypothesis that a high energy intake was associated with a greater BMI z-score. The present study observed a positive association between total energy intake (kcal per day) and BMI z-score, and overweight/obesity. However, relative energy intake (kcal per kilogram body weight) was not significantly associated with BMI z-score after adjustment for confounders. These findings are consistent with equivocal results reported in earlier studies, and highlight that the association between energy intake and childhood obesity is unclear (Gazzaniga and Burns, 1993; Rodríguez and Moreno, 2006; Saker et al., 2011).

While a positive association between total energy intake and BMI z-score in children has been reported in earlier studies (Cowin and Emmett, 2000; Saker et al., 2011; Hebestreit et al., 2014), others have failed to find such an association (Tucker et al., 1997; Aeberli et al., 2007), and some have found energy intake in overweight and/or obese children to be significantly lower than their leaner peers (Maffeis et al., 1998; Rocandio et al., 2001). This is not unexpected, since overweight/obese children have larger amounts of fat mass, which is less metabolically active than fat-free mass. Therefore, in contrast to leaner children, overweight/obese children may have lower resting energy expenditure per kilogram of body weight (Maffeis et al., 1993). This difference in body composition could contribute to the lower energy intake per kilogram of body weight.

In the current study, carbohydrate intake, expressed as a percentage of energy, was associated with a -0.23 lower BMI z-score ($p=0.01$) following the adjustment of confounders. Carbohydrate intake relative to body weight was also found to be inversely associated with BMI z-score. Although, evidence for an association between carbohydrate intake (expressed as a percentage of energy intake or adjusted for body weight) is inconsistent in the literature (Atkin and Davies, 2000; Cowin and Emmett, 2000), this inverse association has been previously reported with adiposity (Nelson and Tucker, 1996) and overweight/obesity in childhood (Gazzaniga and Burns, 1993; Tucker et al., 1997). A diet high in carbohydrates may reduce obesity risk in several ways. Firstly, carbohydrates have a lower energy density compared with lipids, and so could reduce overall energy intake. Secondly, complex polysaccharides are characterised by slower digestion and absorption, and lastly, complex carbohydrates are found to be more satiating than fats (Birch, 1992; Gibson, 2000; Pereira and Ludwig, 2001).

Fat intake, expressed as a percentage of energy intake, was found to be positively associated with BMI z-score in the present study. Whilst the evidence in the literature is inconsistent, findings of the current study agree with several studies showing a positive association between the percentage of energy from fat and obesity in childhood (Gazzaniga and Burns, 1993; Maffeis et al., 1998; McGloin et al., 2002). For example, Maffies et al. (1998) showed a significant association between fat intake and adiposity, although this association was confounded by parental BMI. Overall, the influence of fat intake on obesity risk in childhood is equivocal. While some studies suggest a positive relationship after adjusting for confounders (Gazzaniga and Burns, 1993; Tucker et al., 1997; McGloin et al., 2002), other cross-sectional and longitudinal studies have failed to find such associations in preschool children (Boulton and Magary, 1995, Davies, 1997)

Several mechanisms have been suggested by which dietary fat plays a role in the development of overweight and obesity. Compared with carbohydrate and protein, fat is more palatable, more energy-dense (Poppitt, 1995), and less satiating (Blundell and Macdiarmid, 1997). Fat intake is more likely to lead to passive overconsumption (Rolls and Hammer, 1995; Magarey et al., 2001; Little et al., 2007). Additionally, in contrast to the storage capacity and oxidation of dietary protein and carbohydrate, excess dietary fat is stored with greater efficiency and therefore fat stores are not tightly regulated (Flatt et al., 1985; Tremblay et al., 1989; Hill et al., 2000).

Previous studies have consistently reported a positive association between protein intake as a percentage of energy and obesity (Rolland-Cachera et al., 1995; Günther et al., 2007; Pimpin et al., 2016). However, similar to other studies (Dorosty et al., 2000; Stunkard et al., 2004), the current study failed to find such association. Unexpectedly, an inverse association was observed between protein intake relative to body weight and BMI z-score, although this association became not significant following adjustment for confounders. Therefore, the relationship between protein and obesity in this population of Emirati preschool children seems ambiguous, and highlights the need for further research, to better understand this association. The high protein intake observed in preschool children in the current study highlights the importance of further exploring the impact of protein on obesity risk, in particular identifying the foods responsible for the high protein intake (e.g. formula milk, cow's milk etc.).

10.3.2 Dietary patterns and obesity

A key aim of the present study was to identify dietary patterns in Emirati preschool children, and to examine their associations with socio-demographic, anthropometric and behavioural factors.

Using principal component analysis, the three dietary patterns identified ('Traditional/health-conscious', 'Processed/Western', and 'Convenience/snack') collectively explained 35.5% of the total variance in diet, with each explaining 16.2%, 10.5% and 8.7% of the variance respectively. The proportion of variance in the dietary data of preschool children in current study was comparable to other studies using PCA, which ranged from 25% to 50% (Nobre et al., 2012; Leventakou et al., 2016; Santos et al., 2016). The three dietary patterns identified were also comparable to those previously derived in preschool children (see systematic review in section 3.5) (Northstone and Emmett, 2005; Craig et al., 2010; Moreira et al., 2010; Rodríguez-Ramírez et al., 2011; Souza et al., 2013). For instance, Northstone and Emmett (2005) identified three dietary patterns (unhealthy, traditional and health-conscious) among children aged 4 and 7 years. The two dietary patterns 'Processed/Western' and 'Convenience/snack' in particular highlight the influence of 'Western' eating habits, which is not surprising in light of the rapid urbanisation and increase in import of Western foods and drinks in the UAE.

Nevertheless, as previously discussed in section 3.4, comparing dietary patterns from different studies is difficult, due to differences in (i) in dietary assessment methods used, (ii) the allocation of foods into food groups for factor analysis, (iii) the number of dietary patterns retained for analyses, and (iv) the statistical tests used to derive dietary patterns, and investigate associations. Also, since data-driven methods, such as principal component analysis, derive patterns from dietary data of the studied population, cultural differences in dietary patterns are expected, and therefore these patterns may not be comparable to other populations.

An *a priori* dietary pattern was also calculated using a previously developed diet quality score in preschool children using international dietary guidelines (Voortman et al., 2015). A high diet quality score represented a diet characterised by high intake of vegetables, fruit, bread and cereals, rice, pasta, potatoes, legumes, dairy; meat, poultry, eggs, and meat substitutes, fish, fats and oils; and low intake of candy, snacks and sugar sweetened beverages (see, Table 6-5). In the current study, the diet quality score was 3.4 on a theoretical scale between 0 and 10. The calculated mean diet score in the current population of preschool children was slightly lower than the diet score (diet score 4.1 standardised to an energy intake of 1200 kcal/d) calculated in a multi-ethnic population of preschool children (n=844) in the Netherlands, which used the same diet quality score (Voortman et al., 2015). This therefore indicates that the overall diet of Emirati preschool children could be better.

Similar to a previous study among Dutch children (Kiefte-de Jong et al., 2013), the present study found a strong agreement and correlation between the traditional/health conscious dietary pattern (high in intake of fruits, vegetables, whole grains, and low in energy-dense processed foods) and diet quality score (Pearson's correlation coefficient: 0.6; $p<0.001$). This therefore confirms that both methods are suitable in identifying a healthy dietary pattern in preschool children, and can be used interchangeably.

In relation to the determinants of dietary patterns, in the current study boys scored high (the highest quintile) for the processed dietary pattern (high in processed foods, red meat, low in fibre, fruits and vegetables). This finding is similar to previous research, which documented that boys tend to consume more processed meats, fried foods, sugary foods and less fruits and vegetables compared to girls (Cooke and Wardle, 2005; Northstone and Emmett, 2005; Moreira et al., 2010). Conversely, mothers with a university degree were found to score highest on the convenience/snack dietary pattern. This is in disagreement with earlier studies, in which healthy dietary patterns that include higher intakes of fruits and vegetables are found to be positively associated with maternal education in Western countries (Aranceta et al., 2003; Northstone and Emmett, 2005). This finding suggests that mothers with a higher educational level (i.e. higher social class), in developing countries like the UAE, have greater access to energy dense-foods and snacks, which could potentially increase the risk of preschool obesity. However, as dietary pattern analysis in this study is limited by the small sample size, larger-scale longitudinal studies are needed to further investigate these associations and explore whether dietary patterns track throughout childhood.

Previously, a low level of maternal education (Aranceta et al., 2003; Northstone and Emmett, 2005; Oellingrath et al., 2010), longer time spent in sedentary activity (Ambrosini et al., 2009) male children (Moreira et al., 2010), overweight/obese mothers (Northstone and Emmett, 2005; Northstone and Emmett, 2008), single parents and families of lower socioeconomic status (Ambrosini, 2014) have been shown to be associated with ‘unhealthy’ or ‘processed’ dietary patterns. These socio-demographic and parental factors are also found to be associated with *a priori* diet scores representing a higher diet quality (Smithers et al., 2011). For instance, a higher score for the Revised Children’s Diet Quality Index used in a study of diet quality in 2- to 5-year-old children was found to be associated with younger child age and higher social class (Kranz et al., 2008). Similarly, the Healthy Eating Index, used to investigate diet quality in a large sample of Greek preschool children, found that higher diet scores were positively associated with maternal education and employment (Manios et al., 2009).

The present study found no association of dietary patterns or diet scores with BMI z-score. As reviewed in Chapter 3 (see section 3.5) the evidence for an association between dietary patterns or diet scores and preschool obesity is inconclusive (Craig et al., 2010; Smithers et al., 2011; Ambrosini, 2014). Although some studies have found associations between PCA derived dietary patterns (Moreira et al., 2010; Rodríguez-Ramírez et al., 2011; Ambrosini, 2014) or diet scores (Acharya et al., 2011; Voortman et al., 2016) and overweight or BMI z-score, others have found no association(Reilly et al., 2005; Kleiser et al., 2009; Manios et al., 2009; Meyerkort et al., 2012). Therefore, the relationship between dietary patterns and risk of overweight and obesity in preschool children is currently unclear.

Overall, however, dietary patterns identified in this study suggest that the diets of Emirati children are suboptimal, and are consistent with the global trend where preschool children consume foods high in fats, refined carbohydrates, bread, animal products and high sugar foods and beverages such as cookies, sugar-sweetened drinks and sweets (World Health Organisation, 2013b). This may have important implications for overweight and obesity prevention strategies targeting preschool children in the UAE.

10.3.3 Strengths

To the best of my knowledge, this is the first study in the United Arab Emirates to define dietary intake and patterns in preschool children, and investigate associations with BMI z-score and overweight/obesity. Furthermore, the study used two approaches: an *a priori* diet quality score and *a posteriori* data driven method (principal component analysis) to provide greater understanding of dietary patterns in this population.

Another strength is the use of food diaries validated against weighed food records and the doubly labelled water method, and shown to be suitable for assessing energy and macronutrient intake in preschool children (Lanigan et al., 2001) (see section 3.2.2.3).

Investigating diets of preschool children is another possible strength. Compared to older children, parents of younger children are less likely to perceive their child to be overweight, and therefore the likelihood of misreporting dietary intake is lower (Livingstone et al., 2004; Syrad et al., 2015). The percentage of plausible reporters (i.e. did not under-report or over-report energy intake) was high in this study (83%), which suggests that the data are reliable and interpretable.

Finally, this study presents novel information on the relationship between energy intake, macronutrient composition and BMI z-score in preschool children in the UAE, which could be useful in informing future policies in the Arabian Gulf region.

10.3.4 Limitations

There are several limitations to this study. The completion and return of food diaries was poor. The difficulties in dietary assessment, especially in preschool children, are well established (see, Tables 3-1 and 3-2) (Livingstone and Robson, 2000). This is also expected in studies involving food diaries, since their completion is considered a lengthy process (Livingstone et al., 2004). This may particularly be difficult in the UAE, where meals are usually eaten together and sometimes children share a large plate with all family members. Therefore, quantifying portion sizes was a difficult task.

Measurement errors may have influenced the study's findings. For instance, while parents were trained to complete the food diaries appropriately, certain foods and drinks consumed outside parental supervision may not have been documented. This can be expected in the UAE, where a large number of Emirati families may share their homes with grandparents, aunts and uncles etc., and many children are fed by domestic helpers, therefore, these factors need to be considered when interpreting findings in this study.

The dietary pattern analysis method is also subjective, including the number of food groups, type of rotation, number of dietary patterns extracted etc. Moreover, dietary patterns derived using principal component analysis are population-specific, thus limiting the generalisability of findings. In contrast, while the diet quality score used in this study was based on pre-defined international dietary guidelines from Western countries (Voortman et al., 2015), these may not be entirely appropriate for transitional developing countries. Therefore, the current study highlights the need for country specific dietary guidelines to better reflect diet quality of preschool children in the UAE.

Although, principal component analysis is widely used to derive dietary patterns in children (Northstone and Emmett, 2008; Smith et al., 2013) , and investigate associations with obesity (Smithers et al., 2011; Ambrosini, 2014), the current study only employed one method of data-driven a posteriori dietary patterns, and did not derive dietary patterns using reduced rank regression which has been suggested to produce more meaningful dietary patterns using intermediary/response variables (e.g. energy density of foods), and may better identify dietary patterns associated with obesity (Hoffmann et al., 2004).

As previously noted, the observational design of the present study prevents conclusions on causality to be drawn. Unmeasured confounding factors may have influenced associations between diet and preschool overweight and obesity, and therefore, findings need to be interpreted with caution.

The current study measured physical activity of children through parental recall, which is subjective and prone to error. However, due to limited resources and time it was not possible to use objective measures (e.g. accelerometers). Therefore, reports of associations between physical activity and dietary intake may not be fully valid in this study.

Lastly, one of the major limitations of the present study is the small sample size, because only 59 food diaries were returned. The small sample may have underpowered the analyses. Although tests used to evaluate the appropriateness of using PCA to identify dietary patterns were satisfactory and appropriate (KMO=0.509, Bartlett's test of sphericity $p<0.001$), the small study population limits the interpretation of dietary patterns identified.

10.4 Study 3: Effectiveness of Eat Right Emirates healthy lifestyle tool: findings of the randomised controlled trial

Findings from Study 1 were not used in the current thesis to inform the development of the intervention in Study 3. This is because early life risk factors (e.g. birth weight, breastfeeding, complementary feeding practices) could not be addressed within the scope of the current PhD. However, Study 2 and earlier studies suggest the diets of children in the Arabian gulf region, including the UAE, are poor, and one possible explanation for this is the lack of nutrition knowledge. Therefore, Study 3 tested in a pilot randomised controlled trial whether using a simple healthy lifestyle tool (Eat Right Emirates), which aimed to influence knowledge of a healthy lifestyle for preschool children, was able to address this knowledge-based problem, and reduce preschool obesity risk in the UAE.

In line with the study hypothesis, the Eat Right Emirates Ten Steps for Healthy Toddlers intervention was found to produce positive effects in anthropometric, dietary and behavioural outcomes compared to controls, 6 months after the intervention.

10.4.1 Primary outcome: change in BMI z-score

At the end of the intervention, BMI z-score was significantly lower in the intervention group compared to the control (mean difference: 0.23; 95% CI: -0.39 to -0.06; p=0.007) after adjusting for baseline BMI z-score, age and sex. Change in BMI z-score between randomised groups was -0.26 lower in the intervention group, compared to controls (95% CI -0.43 to -0.09; p=0.004).

The change in BMI z-score in the intervention was in strong agreement with effect sizes reported in recent systematic reviews of interventions aiming to prevent obesity in preschool children (Waters et al., 2011; Ling et al., 2016). The observed -0.26 mean difference in BMI z-score change between the intervention group and controls also matches the mean difference of 0.26 (95% CI: -0.53 to 0.00) reported in the latest Cochrane review for obesity prevention interventions in children aged between 0 and 5 years of age (Waters et al., 2011), and a more recent systematic review and meta-analysis of preschool obesity prevention interventions by Ling et al. (2017), which reported a reduction in BMI z-score (pooled mean difference: -0.19, 95% CI: -0.35 to -0.08).

The Eat Right Emirates tool appeared to have a ‘preventative effect’ because BMI z-score within subjects in the intervention group was little changed after six months, but significantly increased in the control group. This suggests that the intervention tool was protective against the development of overweight and obesity in preschool children (Ling et al., 2017). However, although the 6-month intervention period in the present study complies with the minimum recommended duration for obesity interventions (Doak et al., 2006), whether these effects can be sustained remains unclear, and longer-term follow-up is needed to inform this.

Evidence from previous interventions for preschool obesity prevention is inconsistent (Campbell and Hesketh, 2007; Waters et al., 2011; Zhou et al., 2014; Ling et al., 2017). While some studies have shown success in reducing or maintaining BMI z-score (Fitzgibbon et al., 2005; Jouret et al., 2009; Zask et al., 2012), others have not (Winter and Sass, 2011; De Bock et al., 2013; Skouteris et al., 2016). This variability of findings could be explained by differences in intervention strategies (i.e. targeting diet, physical activity or both), study duration and setting, and differences in mode of delivering the intervention (Ling et al., 2017). Nevertheless, several factors have been suggested to improve the efficacy of obesity interventions aiming to prevent preschool obesity. These include: involvement of parents as ‘agents of change’ (Golan, 2006; Knowlden and Sharma, 2012); provision of information and resources to encourage lifestyle changes within the home environment (Waters et al., 2011); use of both nutrition and physical intervention strategies; and lastly, ensuring that the intervention is culturally appropriate (Hesketh and Campbell, 2010; Ling et al., 2016).

Given the multifaceted nature of obesity (Monasta et al., 2010), and that parents play a primary role in shaping and developing a child’s dietary and physical activity behaviours (Golley et al., 2011), preventative strategies involving parents to target multiple obesity related behaviours are likely to be most effective (Campbell and Hesketh, 2007; Birch and Ventura, 2009; Hesketh and Campbell, 2010; Waters et al., 2011; Ling et al., 2016). However, interventions primarily focused on parental involvement vary in relation to the 'intensity' of their involvement.

The present intervention focused on providing parents with simple, evidence-based advice on nutrition and physical activity in the form of a leaflet. Thus, the 'one-off' nature of this intervention makes it difficult to compare with other more 'intensive' interventions that focus on motivational interviewing, group sessions and home-visits. Nevertheless, the effectiveness of the Eat Right Emirates tool was comparable to the Healthy Habits Healthy Homes Trial (Haines et al., 2013), which found that motivational interviewing in preschool, minority, US children reduced BMI at 6 months post-intervention. However, another home-based intervention, by Harvey-Berino and Rouke (2003), which focused on parental support, showed no effect on weight-related outcomes after 16 weeks. These observations confirm findings recently reported by Ling et al. (2017) that face-to-face delivery of interventions to parents do not necessarily produce greater effects than other modes of delivery (e.g. mailing, phones and websites) (Ling et al., 2017).

To the best of my knowledge, little research has been conducted to prevent or manage overweight and obesity in the UAE, despite the urgent need to curb the rising prevalence of this public health problem in both young and older populations (Ng et al., 2014). However, it is well established that the level of nutrition knowledge and awareness in the UAE, as well as in neighbouring Arab Gulf countries, is low (El-Sabban and Badr, 2011; Musaiger et al., 2013). Therefore, a lack of information has been suggested to be a barrier against the adoption of healthy eating and physical activity habits in adolescents and adults (Musaiger et al., 2013; Scott et al., 2015). Moreover, since the main drivers of childhood obesity remain unclear in the UAE (see section 2.4), this study aimed to pilot an educational approach suitable to the level of awareness and knowledge of nutrition. The current study suggests that the Eat Right Emirates tool providing information on healthy eating and nutrition to parents of young children may be an effective method to increase knowledge and nutrition awareness, and potentially prevent preschool overweight and obesity in the UAE.

Although earlier studies in adults have shown promising effects in using leaflet-based interventions to reduce obesity risk (Black et al., 1984; Beeken et al., 2017), the current study is the first randomised controlled trial to show such results in preschool children. However, it is vital that this intervention is tested in other populations to test its generalisability.

10.4.2 Diet-related outcomes

The Ten Steps for Healthy Toddlers leaflet focused on dietary guidance including advice on limiting processed foods, establishing a routine for meal times and snack, and offering foods from five food groups each day using a helpful guide with portion sizes suitable for preschool children (see **Appendix S**). Children randomised to the intervention group had significant improvements in dietary outcomes. Therefore, in consideration of the limited nutrition knowledge previously reported in the UAE, these steps collectively seem to have positively influenced dietary intake.

At 6-month follow-up, children in the intervention group showed a significantly decreased intake of energy (adjusted mean difference: -4.50 kcal/kg/d ; 95% CI: -8.09 to -0.91; p=0.02), compared to controls. This effect was also observed for fat intake (adjusted mean difference: -0.5 g/kg/d, 95%CI: -0.7 to -0.3; p<0.001). Additionally, within subject change analyses showed that energy and fat intake were significantly decreased in the intervention group, but remained unchanged in the control group. These differences suggest that the intervention may have raised awareness among parents with regard to unhealthy foods, with parents responding by reducing their children's intake of energy-dense foods (e.g. crisps and fried foods), and increasing intake of fruits and vegetables. However, it is not clear on whether this effect was due to the information provided, or whether parents were more compelled to report 'more desirable' answers.

At the end of the 6-month intervention, carbohydrate intake, as a percentage of energy intake, was found to have increased in the intervention group (mean difference: 2.0; p=0.01), but not in the control group. This increase in carbohydrate intake, expressed as a percentage of energy, may have important implications because carbohydrate intake was shown to be a risk factor for preschool overweight and obesity in the UAE.

Interestingly, at 6-month follow-up, intake of protein had significantly increased in the intervention group compared to controls. This coincided with an increase in fish intake in the intervention group but not controls as shown by the fish diet score. The increase could have been a result of parents incorporating more protein-rich foods into their children's diet, because the Eat Right Emirates leaflet (see **Appendix S**) advised on including two to three portions of meat, fish, eggs, nuts and pulses each day. Thus, suggesting that the intervention could have increased the intake of animal proteins, such as fish.

In line with the study hypothesis, the Eat Right Emirates tool resulted in a higher diet quality score in the intervention compared to the control group (adjusted mean difference: 2.69, 95% CI 2.03 to 3.36). These benefits were also observed for single dietary components that comprised the overall diet score. In particular, the intervention increased fruit and vegetable intake, and decreased candy and sugar-sweetened beverage intake. The intervention also had favourable effects on diet-related behaviours, such eating behaviour and enjoyment of food. This suggests that after the intervention children were calmer, more attentive during meals, ate more slowly, and enjoyed tasting new foods including fruits and vegetables. Although the Eat Right Emirates tool improved the dietary intake and quality of children, as dietary habits are suggested to track into later childhood, it would be interesting to investigate whether the effects of this intervention are sustained.

Similar to findings in the present study, other parent-focused interventions have shown positive effects on preschool children's diets. McGowan et al. (2013) demonstrated in an exploratory cluster randomised controlled trial that the use of habit formation theory was effective in a parent-focused intervention (Healthy Feeding Habits); this aimed to encourage healthy feeding behaviours in 2- to 6-year-old children and increased their intake of vegetables, healthy foods as snacks, and water intake (McGowan et al., 2013). Other studies involving parents that have also shown success in improving the diet quality of children (Spence et al., 2013; Skouteris et al., 2016) suggest that such interventions may help to prevent preschool obesity.

10.4.3 Behavioural outcomes

Interventions focused on increasing physical activity or reducing sedentary behaviour in preschool children have yielded inconsistent evidence (Temple et al., 2014). While some have reported increases in objectively measured physical activity (Fitzgibbon et al., 2005; Trost et al., 2008; Annesi et al., 2013a), others have found no effect (Reilly et al., 2006; Alhassan et al., 2007; De Bock et al., 2013). In this study, the intervention significantly increased physical activity and reduced time spent in sedentary behaviours compared to controls. This may be a result of parents encouraging physical activity for at least three hours per day, and limiting television/screen time to one hour per day, as advised in the leaflet. However, since these behaviours were subjectively measured, these results could be spurious, and further research using objective measures of physical activity (e.g. accelerometers) is required.

10.4.4 Strengths

To my knowledge, this is the first investigator blind RCT that used a simple informative leaflet to encourage a healthy lifestyle and help prevent overweight and obesity in preschool Emirati children.

The Eat Right Emirates tool was developed using evidence-based information and a consensus approach. The clear and simple steps made this intervention tool highly accessible and acceptable, as suggested by the high compliance in all parents (100%) in the intervention group, and low dropout rate (5%) in the control group. As many ‘intensive’ obesity interventions that involve parental involvement are often unsuccessful due to a high dropout rate, the less intensive nature of the Eat Right Emirates tool may be a major advantage. Also, although cost-effective (economic) analysis was not conducted, the simplicity and low burden on investigators and participants suggests that this intervention could be a cost-effective and feasible option for larger-scale testing and implementation.

Parents' (mostly mothers') feedback on the intervention was very positive. In particular, mothers highlighted the usefulness of the portion size information. However, formal qualitative evaluation of the ERE is needed to accurately measure parental perception of the intervention, and to better understand which components within the 10 steps healthy lifestyle tool they felt were most beneficial and helpful.

10.4.5 Limitations

This present study has several limitations. Firstly, although, the Eat Right Emirates intervention tool demonstrated a 'preventative effect' at 6 months compared to usual care in the study population, one limitation of the current study was that the intervention was piloted/tested without a formal intervention development framework or procedures (e.g. UK Medical Research Council framework for developing complex interventions), and therefore does not provide cohesive information about intervention development process and evaluation. Another limitation of the intervention is that although the ten steps was informed by theory, the tool was not based explicitly on one specific health behaviour change theory. Therefore, employing an intervention development framework would better inform the development of future interventions.

The lack of qualitative analyses before the commencement of the study limited the ability of the current study to identify specific behaviours (e.g. those relevant to the Arab culture) that should be targeted. Also, due to the lack of in-depth qualitative feedback following the intervention, it was not possible to identify which of the ten steps was beneficial. The development of future interventions would require greater qualitative evaluation in order to: (i) provide further understanding of the study population (e.g. parents' perceptions of their child's weight status in the UAE); and (ii) better explain parents' acceptance of the intervention, and their opinions after completion of the study.

The intervention tool was adapted to suit the Arabian culture (i.e. translated to Arabic, and foods were modified to suit the Middle Eastern diet). However, the absence of a formalised process to culturally adapt the intervention to the needs of the current study population may have limited the intervention. This highlights the need of better processes to culturally adapt interventions to suit their target population. For instance, identifying cultural factors that may influence acceptability of the intervention through focus groups, and taking into consideration the cultural norms by actively involving the target group in the development of the intervention would have been useful and more appropriate.

The relatively short follow-up at 6 months (the end of the intervention) from baseline, limits conclusions on long-term effects of the intervention. However, this limitation is commonly observed in similar intervention studies, in which short-term benefits are often lost at long-term follow-up (Yavuz et al., 2015). A longer follow-up, ideally one year after the end of the intervention, would better evaluate the sustained effects of the intervention. However, due to the limited time constraints within the PhD, only a 6-month follow-up was feasible.

The current study was confined to one location, which was the only school that granted permission. Therefore, in addition to the small sample size, which limited the generalisability of findings, confining the study to one school that enrolled children from a higher social class. Also, because parents were aware of the study aims, one source of bias could be that only concerned parents consented to take part in the study, and those that participated could have been most motivated to change behaviour, leading to more favourable results. This may also explain the low response rate (i.e. only 150 out of 402 parents of children enrolled at the school consented to participate). Another source of bias is cross-contamination, whereby parents in the control group may have changed their child's diet in response to increased awareness in the school. However, this would have made it more difficult to show a difference between the intervention and control groups, and therefore would have reduced the 'effect size' of the intervention.

As highlighted in earlier limitations, parent-reported physical activity and sedentary questionnaires such as those used in the current study can be highly subjective. Although, ideally, objective measures (e.g. accelerometers) of physical activity would have been a better option to investigate the effect of the intervention on activity-related behaviours, this was not possible within the framework of the current PhD.

Moreover, the small sample size of dietary data (n=59) could have underpowered the effect sizes observed between groups; therefore, these findings need to be interpreted with caution. Another limitation is that the study was not able to investigate the effect of the intervention on a *posteriori* derived dietary patterns, as the small sample violates statistical assumptions for principal component analysis.

10.5 Summary

In summary, the cross-sectional study showed that longer duration of breastfeeding, and later introduction of complementary foods were associated with a lower BMI (Study 1). In Study 2, protein intakes in preschool children in the UAE exceeded UK recommendations, but did not meet the recommended intake of fibre. Carbohydrate intake as a percentage of energy was associated with a lower BMI z-score, whereas fat intake as a percentage of energy was associated with a higher BMI z-score. Two methods of dietary pattern analysis were used to identify dietary patterns, and investigate the quality of preschool diet in the UAE: (i) an a priori derived diet quality score; and (ii) principal component analysis. Three dietary patterns were derived using principal component analysis: (i) ‘traditional/health-conscious’; (ii) ‘processed/western’; and (iii) ‘convenience/snack’. Although, a *priori* derived diet score found diets of preschool children were suboptimal, no associations were found between dietary patterns and BMI z-score.

In the current study, it was not possible to influence early life risk factors (e.g. breastfeeding and complementary feeding). However, taking into account that no study to date has investigated diets of preschool children, and based on the previous literature in the in the UAE (AlJunaibi et al., 2013) and Arabian Gulf region (Musaiger et al., 2013) that suggests there is a lack of nutrition knowledge. Study 3 was used to investigate whether a simple knowledge based tool could improve nutrition knowledge and practice in the region. Study 3 found that the

Eat Right Emirates tool was effective in improving the diets of preschool children and reducing obesity risk compared to controls at 6 month follow up. Therefore, this pilot study suggests that a simple intervention is a promising approach for the prevention of preschool obesity in the UAE.

Collectively, within the scope of the PhD the current thesis provided useful findings, attempted to bridge together gaps in the literature, and highlighted the need of future studies to better investigate risk factors of preschool obesity in the UAE, and improve the development process and evaluation of the Eat Right Emirates tool'. The implications and future of this work is further discussed in the next section.

10.6 Implications

The importance of early prevention of obesity is recognised as a key step in curbing obesity worldwide (Birch and Ventura, 2009), since dietary habits and behaviours established during these years track into later life and influence later obesity risk (Birch and Fisher, 1998; Trost et al., 2003). Focusing preventative efforts on preschool children is therefore crucial, because children in these formative years are more malleable and obesity-related risk factors can be more easily changed (Campbell and Hesketh, 2007).

Specifically, the findings in this thesis suggest three major areas. Firstly, promoting a longer duration of breastfeeding, and later introduction of complementary foods (more than 4 months) may help protect against obesity in the UAE. Although, in the UAE mothers are routinely counselled on breastfeeding as part of the WHO/UNICEF Baby Friendly Hospital Initiative (World Health Organisation, 2009), infant feeding practices are still suboptimal, and many mothers introduce solids prematurely (Radwan, 2013; Gardner et al., 2015). Therefore, in consideration of the barriers that may influence breastfeeding and infant feeding practices in the UAE, it may be valuable that policies are tailored to support and maintain breastfeeding in working mothers across all governmental and private sector, as it may be important to raise awareness and increase maternal knowledge on the benefits of breastfeeding and appropriate timing of solid introduction for short- and long-term benefits.

In addition, this study highlights the importance of providing support for mothers during pregnancy and after birth, as many mothers may not be aware of the implications of their own dietary habits on their child's BMI and later obesity risk. Therefore, targeted interventions should aim to start in the antenatal period to promote maternal health during pregnancy and postpartum, encourage healthy dietary behaviours and provide adequate education on infant feeding practices to prevent the long-term risk of overweight and obesity. These include improving mothers' perceptions of their child's weight status. In the UAE, 'plumpness' is a desirable feature in infants and children; therefore, in light of these cultural influences, focusing efforts on parental awareness and recognition of childhood obesity may also have key implications in obesity prevention.

The present study also highlighted that the diet quality of children in the UAE was poor. Therefore, keeping in mind that dietary patterns established in the preschool years are found to track into later life, it is important that public health efforts focus on providing parents, caregivers, and teachers with appropriate nutritional education and tools to promote healthy eating. This advice may be provided as a simple healthy lifestyle tool in the form of a leaflet, which could effectively be used as a preventative strategy in populations that lack basic nutrition knowledge and awareness. Overall, these findings contribute to a better understanding of what is needed in the UAE, and may help inform public health agencies or governmental bodies, in order to develop and design culturally appropriate obesity prevention interventions

10.7 Recommendations for future work

Although there are significant limitations in this thesis, the findings provide clear implications for future research to further identify risk factors responsible for the rising prevalence of preschool obesity in the UAE. The findings presented in the randomised controlled trial also provide valuable information for future interventions to tailor information and prevention strategies to suit the Emirati population. The findings in this thesis could have important practical implications for designing future interventions to prevent preschool overweight and obesity in the UAE.

Risk factors identified in this study are just the tip of the iceberg in relation to preschool obesity in the UAE, and therefore, further investigation of potential risk factors is warranted. In particular, prospective studies would provide a better understanding of the longitudinal relationship between risk factors (e.g. social, environmental, parental, behavioural and dietary) in preschool and obesity in later childhood in the UAE. Furthermore, objective measures of physical activity, sleep duration, adiposity (of parents), and sedentary behaviour would greatly increase the quality and strength of the data.

This research has identified an absence of food-based dietary guidelines for children in the UAE and the need to develop such guidelines in order to provide dietary advice for parents of preschool children in this region. Valid dietary assessment tools are also sought for to provide a better understanding of current dietary behaviours, and investigate associations with obesity.

Future evaluation of dietary patterns in a larger representative sample would provide a more accurate assessment of dietary patterns in preschool children in the UAE. Whist this current research utilised only two methods to derive dietary patterns; an a priori diet quality score, and an a posteriori data-driven method: principal component analysis. It would also be useful for future studies to derive dietary patterns using reduced rank regression, which would better explain linear functions of foods that best explain the variation in outcome variables (e.g. obesity-related nutrients such as energy density, fibre density and percentage of energy from fat) (Hoffmann et al., 2004; Ambrosini, 2014). It would also be useful to monitor and track dietary patterns and examine associations with later obesity risk.

Further research is warranted to examine the efficacy of the Eat Right Emirates intervention tool in a larger representative population and other settings (in the UAE and neighbouring Arab Gulf countries), and to investigate the cost-effectiveness of this simple intervention tool as an alternative to 'intensive' intervention programmes. Future evaluation of the Eat Right Emirates intervention tool in a cluster randomised controlled trial design would also prove useful, including longer-term follow-up to assess sustainability. Moreover, given that the level of current nutrition knowledge is unknown, future interventions should qualitatively assess nutrition awareness, in order to inform the design of appropriate interventions aiming to improve nutrition knowledge and dietary and physical activity habits of the society at large.

In view of the limitations related to the intervention development, a formalised process of developing and evaluating such an intervention would be useful for future work. For instance, by utilising the UK Medical Research Council framework for developing complex interventions (Craig et al., 2008). The process should include a clear *development* process: (i) clear identification of existing evidence base to better understand what is already known, such that a systematic review should be carried out to provide up to date evidence about the study population (e.g. prevalence of the problem, risk factors of childhood obesity, obesity prevention interventions); (ii) Identifying and developing theory by using existing evidence and theory, as well as taking into account the attitudes/beliefs of the target population through focus groups/interviews; (iii) Modelling process and outcome usually involves linking behavioural determinants to behaviour and outcomes. Development of future interventions would require clearer identification of behavioural targets, their expected mode of action, and include a theoretical basis for these behavioural changes. For instance, in relation to the Eat Right Emirates tool, it would be useful to better understand how the target behaviour (e.g. whether parent child-feeding behaviours in *Step 1* would impact a child's dietary intake and feeding behaviours), and if these changes in behaviours in turn may lead to 'healthier' dietary habits, and lower risk of overweight/obese.

Following the development phase, the *feasibility and piloting methods* should be assessed to: (i) test the acceptability of procedures, compliance and the process of delivering the intervention; (ii) provide an estimation of recruitment and retention by identifying barriers; and (iii) determine a robust sample size taking into consideration the anticipated effects size of the pilot testing.

Evaluation of the intervention would allow: (i) evaluation of the effectiveness of the intervention in a randomised controlled trial, which would provide data on predictors, mediators and possible adverse effects; (ii) understanding of the change processes, would also provide useful insights on why an intervention worked, why an intervention failed or how it can be optimised. Process evaluation should also be conducted to assess the fidelity (e.g. using pre-specified checklists) and overall quality of intervention delivery (e.g. qualitative study to provide in depth feedback and identify key factors that may be included in future interventions); (iii) cost effectiveness analysis should be included, in order to provide useful information for policy makers. Lastly *implementation* should be commenced taking into consideration preliminary findings.

Inevitably, to better evaluate the effectiveness of the Eat Right Emirates tool, greater understanding of the research process (recruitment, assessment, retention, acceptability, feasibility and cost-effectiveness) in this study population is warranted. However, although the current study did not employ the recommended intervention development framework, due to the lack of resources and time within the setting of a PhD. The findings of the current study may provide pilot or preliminary data, which could help develop appropriate knowledge-based interventions for the current study population; help inform a more robust power calculation for potential interventions; and provide insight on user-feedback and acceptability of such interventions.

10.8 Conclusion

The work presented this thesis helps to better understand the influence of risk factors on preschool obesity in the UAE. These findings highlight the importance of identifying risk factors in preschool children, and suggest that early preventative strategies should focus on mothers in order to promote appropriate infant feeding practices. The findings of the study using the Eat Right Emirates intervention tool suggest that simple and easily disseminated information could be a stepping-stone towards the prevention of preschool overweight and obesity in the UAE and neighbouring Arab Gulf countries.

'Children are our greatest treasure, they are our future'

Nelson Mandela

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Appendices

Appendix A Search strategy for systematic review – Chapter 1

Search strategy for MEDLINE using OVID interface Dates January 1990 to July 2016
Limits English language and humans, child, preschool (2 to 5 years)

1. exp obesity/
2. exp overweight/
3. exp overweight/
4. exp paediatric obesity/
5. exp body fat/
6. exp body mass index/
7. exp body weight/
8. BMI
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10. *child, preschool/
11. *child$/
12. toddler$
13. kindergarten
14. 10 OR 11 OR 12 OR 13
15. Middle East/
16. exp Bahrain/
17. exp Saudi Arabia/
18. exp Oman/
19. exp United Arab Emirates/
20. ‘UAE’
21. exp Kuwait/
22. exp Qatar/
23. Gulf Cooperation Council/
24. 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23
25. exp cross-sectional studies/
26. exp prospective studies/
27. exp longitudinal studies/
28. 25 OR 26 OR 27
29. Prevalence (MeSH)
30. Rate
31. Trend
32. 29 OR 30 OR 31
33. 9 AND 14 AND 24 AND 28 AND 32

Appendix B Data extraction form adapted from the Cochrane Collaboration

This form has been developed by adopting and customising the data collection form for intervention reviews (RCTs and non-RCTs) of the Cochrane Collaboration. Sections have been amended, and irrelevant sections have been removed (e.g. intervention info). Information included in this form was used in three systematic reviews included in this thesis.

General information		
Date form completed		
Name of person completing data extraction		
Title of review		
Name of person checking extracted data		
Eligibility		
Study Characteristics	**inclusion criteria of review**	**Location**
Type of study *(cross-sectional, cohort, prospective, case-control, retrospective)*		
Description of study participants		
Focused disease or condition *(overweight, obesity, adiposity, at least one)*		
Types of outcome measures (*prevalence, risk factors)*		
Reason for inclusion or exclusion		
INCLUDE ☐ EXCLUDE ☐ ***Do not proceed if study excluded from review***		
Population and setting		
	Description as stated in paper	**Location**
Description of study population *(including setting e.g. urban, rural, ethnic group)*		
Method of recruitment		
Methods		
Aim of study		
Design *(e.g. cross-sectional, prospective, cohort)*		
Sampling technique *(random or convenience)*		
Study start date		
Study end date *(duration if any cohort)*		
Participants		
Number of participants/sample size		
Age group (*age range)*		
Outcome ** use for each outcome*		
Outcomes *(methods used to measure outcome, objective, questionnaires, self-reported)*		
Is outcome tool validated *(yes, no, not mentioned)*		
Type of measurement *(Percentage/Odds ratio)*		
Results and Findings		
Outcome		
Sub-group *(specific age group (preschool), specific prevalence reporting*		
Result*s (incl. any other relevant results, e.g. weighted results)*		
Statistical methods used *(%, Mean(SD), ORs etc.)*		
Notes (incl. key conclusions and any other relevant information)		

Appendix C Search strategy for systematic review – Chapter 2

Search strategy for MEDLINE using OVID interface: Dates 1980 to November 2016
Limits English language and humans, child, preschool (2 to 5 years)

1. exp obesity/
2. exp overweight/
3. exp overweight/
4. exp paediatric obesity/
5. exp body fat/
6. exp body mass index/
7. exp body weight/
8. BMI
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10. *child, preschool/
11. *child$/
12. toddler$
13. kindergarten
14. 10 OR 11 OR 12 OR 13
15. risk factors/
16. determinants/
17. diet*
18. dietary/
19. behavioural/
20. physical activity
21. sedentary behaviour
22. television viewing
23. sleep duration
24. socioeconomic status
25. maternal education
26. parental obesity
27. maternal obesity
28. parental smoking
29. infant feeding/
30. breastfeeding/
31. formula feeding/
32. complementary feeding/
33. solid foods/
34. rapid infancy growth
35. infant size/
36. birth weight/
37. 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 31 OR 32 OR 33 OR 34 OR 35 OR 36
38. Middle East/
39. exp Bahrain/
40. exp Saudi Arabia/
41. exp Oman/
42. exp United Arab Emirates/
43. ‘UAE’
44. exp Kuwait/
45. exp Qatar/
46. Gulf Cooperation Council/
47. 38 OR 39 OR 40 OR 41 OR 42 OR 43 OR 44 OR 45 OR 46
48. exp cross-sectional studies/
49. exp longitudinal studies/
50. exp cohort/
51. 48 AND 49 AND 50
52. 9 AND 24 AND 37 AND 51

Appendix D Downs and Black checklist: Quality Assessment Sheet

REVIEWER'S NAME	
AUTHOR(S) and YEAR	
QUALITY ASSESSMENT QUESTIONS	**SCORE**
REPORTING *	**(yes 1 / no 0)**
1. Is the hypothesis/aim/objective of the study clearly described?	
2. Are the main outcomes to be measured clearly described in the introduction or methods section?	
3. Are the characteristics of the participants included in the study clearly described?	
4. Are the dietary interventions of interest clearly described?	
	(yes 2 / partially 1 / no 0)
5. Are the distributions of principal confounders in each group of subjects to be compared clearly described? List of potential confounders.	
	(yes 1 / no 0)
6. Are the main findings of the study clearly described?	
7. Does the study provide estimates of the random variability in the data for the main outcomes?	
8. Have the characteristics of participants lost to follow-up been described?	
9. Have actual probability values been reported (e.g. 0.035 rather than <0.05) for the main outcomes except where the probability value is less than 0.001? If only actual values for non-significant results (i.e. 0.06) reported the question should be answered no.	
EXTERNAL VALIDITY*	**(yes 1 / no 0 / unable to determine 0 / NA)**
10. Were the participants asked to participate in the study representative of the entire population from which they were recruited?	
11. Were those participants who were recruited to participate representative of the entire population from which they were recruited?	
INTERNAL VALIDITY – BIAS *	
12. Was an attempt made to blind those measuring the outcomes of the intervention?	
13. If any of the results of the study were based on "data dredging", was this made clear?	
14. Were the statistical tests used to assess the main outcomes appropriate?	
15. Were the main outcome measures used accurate (valid & reliable)?	
INTERNAL VALIDITY - CONFOUNDING (SELECTION BIAS) *	
16. Were the participants in different intervention groups (trials and cohort studies) or were the cases and controls (case-control studies) recruited from the same population?	
17. Were study participants in different intervention groups (trials & cohort studies) or were the cases and controls (case control studies) recruited over the same period of time?	
18. Was there adequate adjustment for confounding in the analyses from which the main findings were drawn?	
19. Were losses of participants to follow-up taken into account?	
POWER *	
20. Did the study have sufficient power to detect a clinically important effect where the probability value for a difference being due to chance is less than 5%? (see Downs& Black checklist for further details)	
ADJUSTMENT*	
21. Were data adjusted appropriately (e.g. account for body size and total energy intake?)	Score 2 fully adjusted/ 1 partially/0 no.

N/A, not applicable *see Downs and Black checklist for further details to answer questions

Appendix E Search strategy for systematic review – Chapter 3

Search strategy for MEDLINE using OVID interface: Dates January 2010 to October 2016

Limits English language and humans, child, preschool (2 to 5 years)

1. exp obesity/
2. exp overweight/
3. exp overweight/
4. exp paediatric obesity/
5. exp body fat/
6. exp body mass index/
7. exp body weight/
8. BMI
9. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7 OR 8
10. *child, preschool/
11. *child$/
12. toddler$
13. kindergarten
14. 10 OR 11 OR 12 OR 13
15. *diet/
16. *energy intake/
17. *food/
18. nutrition assessment/or nutrition surveys/
19. dietary carbohydrates/
20. dietary fat/
21. dietary protein/
22. beverages/
23. food habits
24. dietary quality
25. western diet
26. prudent diet
27. dietary pattern/
28. principal component analysis
29. reduced rank regression/
30. cluster analysis/
31. factor analysis/
32. Diet score/
33. Diet index/
34. Diet quality
35. Eating Index
36. 15 OR 16 OR 17 OR 18 OR 19 OR 20 OR 21 OR 22 OR 23 OR 24 OR 25 OR 26 OR 27 OR 28 OR 29 OR 30 OR 32 OR 33 OR 34 OR 35
37. longitudinal studies/
38. exp intervention studies/
39. exp prospective studies/
40. exp cross-sectional studies/
41. exp follow-up studies
42. 37 OR 38 OR 39 OR 40 OR 41
43. 9 AND 14 AND 36 AND 42

Appendix F Behaviour change theories

Theory	Key concept
Health Belief Model	Based on six main constricts that influence an individual's decision or motivation to act, prevent, monitor or manage a disease. These include: (i) *perceived susceptibility*, an individual is ready to act if they believe they are vulnerable to a specific disease/condition; (ii) *Perceived severity*, believe that a disease has serious consequences, (iii) *Perceived benefits*, consider taking action to reduce the risk of disease/condition; (iv) *Perceived barriers*, trust that the cost of taking action, are compensated by the benefits; (v) *Cue for action*, are exposed to factors that may encourage action, and (vi) *Self-efficacy*, individuals are optimistic and confident in their ability to successfully achieve an action (Glanz & Saelens, 2010).
Stages of Change Theory	Key element of the Transtheoretical model (Prochaska & DiClemente, 1997), which proposes that behaviour change is a process, and individuals are often at different stages of readiness to change behaviour (Prochaska et al., 2008), and shift between five main stages of a cycle. That usually starts with: (i) *Precontemplation*, individuals do not recognise the need for change; (ii) *Contemplation*, as individuals develop awareness, they may begin to think about change; (iii) *Preparation*, individuals may seek support and prepare an action plan; (iv)*Action*, refers to the actual adoption of new behaviours or habits, and (v) *Maintenance*, is considered an on-going process in which individuals may work to keep the attained behaviour (Prochaska et al., 1992).
Theory of Planned Behaviour	Stems from the Theory of Reasoned Action (Ajzen, 1991) which focuses on the relationships between behaviour and beliefs, attitudes, intentions and subjective norms (Montano & Kaspryzk, 2008).
Social Cognitive Theory	Stems from the Social Learning theory proposed by Bandura (1977), which explains human behaviours in terms of a three-way reciprocal model, whereby personal factors, environmental influences and behaviour continually interact. A basic principle of the social cognitive theory is that people learn not only through their personal experiences, but also by observing the actions of others, and the benefits of these actions (Bandura, 1986). The main constructs of social cognitive theory applicable to childhood obesity prevention include observational learning (modelling), reinforcement, self-control and self-efficacy (Glanz, 1997).
Behaviour Learning theory	One of the key constructs of Behavioural learning theory is operant conditioning, whereby behaviours are carried out in response to stimuli. Unlike other theories that require thoughts and cognitions to explain behaviour, this theory focuses on gaining control over the stimuli and/or reinforcers in an individual's life, by only on reinforcing desired behaviours in order to reduce undesirable behaviours (Baranowski et al., 2003).
Consumer information processing	The main principal behind Consumer information processing theory is that people can only process a limited amount of information at a given time, and often individuals may only seek enough information to make a choice (Rudd & Glanz, 1990).

Appendix G Description of Ten Steps for Healthy Toddlers leaflet

Tip	Recommendations and Scientific evidence
1. Eat together as a family and make meal times relaxed, happy occasions	
Make food easy to eat – finger foods are good. Eat the foods that you would like your toddler to eat. Praise your toddler when he or she eats well or tries something new – toddlers take time to learn to like new foods.	Eating together as a family is an important social time in family life as well as a learning opportunity for toddlers. They learn to eat different foods and improve their self-feeding skills by watching what, and how, other members in the family or social group eat. Eating a healthy balanced diet of nutritious foods with their toddlers, parents will be encouraging their toddlers to like and enjoy those same nutritious foods, building an excellent foundation for future food choices.
2. You decide which nutritious foods to offer but let your toddler decide how much	
Never insist your toddler eats everything on his or her plate	Toddler's appetite varies (e.g. they may eat well at some meals but much less at others). Parents often overestimate the amount of food their toddlers needs even in the case their child is no longer hungry. Therefore, it is important that parents offer nutritious foods at meal and snack time, and allow their toddler to eat the amount the toddler's appetite demands. This is important because toddlers that eat more than they need are more likely to become overweight. See section 3.3.3.1
3. Offer foods from all five food groups each day	
Together they give the right mix of nutrients.	Providing children with foods from five food groups (Appendix 0) 1. Bread, rice, potatoes, pasta and other starchy foods, 2. Fruits and vegetables, 3. Milk, cheese and yoghurt, 4. Meat, fish, eggs, nuts and pulses, 5. Oils, butter and fat spreads, provides toddlers with a nutritious balanced diet, and supplies a combination of nutrients. Sugar foods should be eaten in smaller and limited quantities as these provide energy, but fewer nutrients
4. Have a routine and offer 3 means and 2-3 snacks each day	
Offer 2 courses at each meal and only offer nutritious snacks. Don't allow grazing on food.	Toddlers need to eat regularly to maintain their energy levels. However, grazing on snacks without a meal routine often leads to consumption of less nutritious foods. A routine of 3 meals and 2 – 3 planned nutritious snacks provides a balanced diet and limits the exposure to sugar in foods and drinks. Offering two courses of different foods at meals will ensure a toddler is consuming a wider variety of nutrients (e.g. a first savoury course of starchy foods and vegetables can be followed by a second course of a fruit or a small nutritious pudding).
5. Offer 6 – 8 drinks a day (Water)	
Give all drinks in a beaker or cup –not bottles. 3–4oz or 100–120ml is about right. Water is a good choice.	Toddlers need to consume adequate amount of fluids to maintain hydration and prevent constipation. Drinks should be offered with each meal and snack, and ensure children drink more drinks in hot weather or when they are active. Parents should discontinue the use of bottles by 12 months, and avoid toddlers in consuming large volumes of milk, which may reduce their appetite for other foods that are higher in iron

Tip	Recommendations and Scientific evidence
6. Give Vitamin A and D each day	
Toddlers don't get enough in their food and need 10 micrograms in a supplement each day.	Even toddlers eating nutritious diets do not get enough of vitamin D. The Department of Health policy Recommends a supplement of vitamins A & D for toddler's dates from 1991. The recommendation for a supplement of vitamin D for all children from birth has been reiterated in subsequent government reports and more recently in NICE, Scientific Advisory Committee on Nutrition (SACN) and Public Health England (PHE) recommendations.
7. Respect your toddler's tastes and preferences – don't force feed	
Some children eat almost everything while others are much pickier. Some like foods kept separate on the plate and others are happy with foods mixed in together.	Parents should offer a nutritious diet that accommodates these preferences as well as always offering the usual family foods. New foods should always be offered in very small portions; on a separate plate from the foods the toddler usually eats. In time and by eating with others, most toddlers will widen their set of food preferences
8. Reward your toddler with your attention-never give food or drink as a reward, or treat or for comfort	
Play, read or talk with your toddler as a reward. Always give fruit or a nutritious pudding – don't use it as a reward for eating other foods first or for good behaviour.	Foods given as a reward for eating other food (e.g. eat up your vegetables, then you can have your pudding), or given as a reward for good behaviour or comfort, are seen by toddlers as more *desirable* foods. If these foods are eaten in excess, sweet and energy dense foods used as reward can contribute to excessive weight gain Parents should focus on providing attention, and praise when the child is eating well, and avoid commenting on refused foods, that can be offered as usual during the next meal.
9. Limit and avoid certain foods	
Limit fried food, crisps, packet snacks, pastries, cakes and Avoid sweetened squashes, fizzy drinks, tea and coffee	Toddlers have an innate preference for high calories palatable foods, particularly sweet food. Therefore these need to be limited to small amounts to avoid excess weight gain (Cooke et al., 2004). See section 3.3.2.4 for more details on the influence of sugar intake on obesity risk
10. Encourage physical activity for at least 3 hours every day and 12 hours of sleep	
All activity such as active play inside and outside, walking, running and dancing counts. Limit TV and other screen time like tablets to just 1 hour a day	The UK department of health recommends that children under the age of five engage in at least 3 hours of physical activity per day (DOH, guidelines). Reducing time spent in sedentary activities (e.g. TV viewing time) is found important in preventing obesity. The ALSPAC study reported that toddlers who sleep less than 12 hours were more likely to become obese at 7 years of age, and three year old children who watched more than an hour of TV each day were more likely to become obese (Reilly et al., 2005). See section 2.3.2 for more details on the influence of physical inactivity, sedentary behaviour and short sleep duration on obesity risk.

Appendix H Poster presentation: Evaluation of Ten Steps for Healthy Toddlers

THE MEASURED OUTCOMES OF DISSEMINATING THE 'TEN STEPS FOR HEALTHY TODDLERS' INTO CHILDCARE SETTINGS

What are the Ten Steps for Healthy Toddlers?

Ten easy-to-follow steps emphasising positive strategies to use in the home and in childcare settings to help parents and carers manage toddler mealtimes and develop health-promoting behaviours in 1-3 year olds.

How can the Ten Steps be used?

- Reassuring and advising parents
- Adoption into policies and procedures in childcare settings
- Staff training and behaviour change in childcare settings
- In Ofsted Self Evaluation Forms
- Supporting all healthy eating initiatives for toddlers as they align with government advice.

Who developed the Ten Steps?

The Infant & Toddler Forum – an expert group comprising paediatricians, health visitors, dietitians and a clinical child psychologist.
www.infantandtoddlerforum.org

Where was the effectiveness of the Ten Steps measured?

The Pre-school Learning Alliance (PLA) adapted their national policies and procedures that are used by their 117 registered childcare settings, to incorporate the Ten Steps. Managers within each setting were asked to:

- commit to a package of activity involving the Ten Steps
- complete pre-adoption and 6 months post-adoption questionnaires.

A comparison of pre- and post-adoption responses were analysed from the 27 settings where managers responded.

What were the measured outcomes of adopting the Ten Steps in 27 childcare settings?

1. Behaviour changes in staff *– following adoption of the Ten Steps:*

On average the 27 childcare settings selected more than 10 behaviours in managing meal and snack times and physical activity that had improved:

- Staff and children interact well at meal/snack times – (**21/27**)
- We are aware that children all have different preferences for tastes of food and the way it is served – (**21/27**)
- We respect each child's decision when they say they have eaten enough – (**21/27**)
- We have a regular daily routine of snacks and mealtimes – (**20/27**)
- Children are encouraged to serve themselves during meal/snack time – (**20/27**)
- We only offer drinks in beakers or cups – (**19/27**)
- Snack and meal times are social and relaxed occasions – (**18/27**)
- We do not use food and drink as a reward – (**18/27**)
- Our children are physically active for at least 2½ hours during a full day at our nursery/in our setting – (**18/27**)
- We only offer water or milk as a drink with meals – (**17/27**).

2. Improved confidence of staff in dealing with meals and snack times

- **25/27** reported their staff found the Ten Steps poster helpful
- **17/27** rated their staff more confident in dealing with feeding issues
- **17/27** reported staff felt better equipped to deal with children with food allergies
- **16/27** reported children are more involved in mealtimes as learning experiences
- **14/27** reported staff are better equipped to deal with challenging behaviours.

3. Positive engagement from parents

- **20/27** had received feedback from parents about the poster - no negative feedback received
- **12/27** settings reported parents engaging with staff about food and physical activity.

4. The three steps rated as the most useful by settings were:

2. You decide which nutritious foods to offer, taking account of individual dietary needs, but let children decide how much to eat

7. Respect children's tastes and preferences – don't force feed

4. Have a routine, offering 3 meals and 2–3 snacks over the whole day

Information about the Ten Steps:

The Ten Steps, has also been cited as best practice by Demos in their For Starters report and other early years' settings e.g. Busy Bees and London Early Years Foundation have committed to rolling it out. Mother and baby websites such as Baby World, Baby Centre and 4Children now cite the resources.

The different formats are:

- an A4 flyer for parents; developed in association with the PLA to ensure the wording of the resource is parent-friendly
- an A3 poster for display in early years settings; also developed with the PLA
- resources on the PLA website and also embedded in the PLA iPhone App – this has had 11,000 downloads with an average 4* rating
- a video produced in collaboration with Parenting UK, which is available for parents to view for free on **Parentchannel.tv.** The video can also be easily embedded on external sites.

Author Contact Details: Judy More, *Paediatric Dietitian, Member of the Infant & Toddler Forum* **info@infantandtoddlerforum.org.uk**

Supported by an unrestricted educational grant from Danone Nutricia Early Life Nutrition.
The views and outputs of the group, however, remain independent of Danone Baby Nutrition and its commercial interests.

Appendix I Ethical approval letter, UCL

UCL RESEARCH ETHICS COMMITTEE ACADEMIC SERVICES

Dr Julie Lanigan
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7 July 2014 Dear Dr Lanigan

Notification of Ethical ApprovalProject ID: 5618/001: Pre-school obesity in the United Arab Emirates: determinants and the effectiveness of the 10-step healthy lifestyle tool for toddlers: Eat Right Emirates study

I am pleased to confirm that your study has been approved by the UCL Research Ethics Committee for the duration of the project i.e. **until September 2015**. Approval is subject to the following conditions:

1. You must seek Chair's approval for proposed amendments to the research for which this approval has been given. Ethical approval is specific to this project and must not be treated as applicable to research of a similar nature. Each research project is reviewed separately and if there are significant changes to the research protocol you should seek confirmation of continued ethical approval by completing the 'Amendment Approval Request Form'.

The form identified above can be accessed by logging on to the ethics website homepage: http://www.grad.ucl.ac.uk/ethics/ and clicking on the button marked 'Key Responsibilities of the Researcher Following Approval'.

2. It is your responsibility to report to the Committee any unanticipated problems or adverse events involving risks to participants or others. Both non-serious and serious adverse events must be reported.

Reporting Non-Serious Adverse Events

For non-serious adverse events you will need to inform Helen Dougal, Ethics Committee Administrator (ethics@ucl.ac.uk), within ten days of an adverse incident occurring and provide a full written report that should include any amendments to the participant information sheet and study protocol. The Chair or Vice-Chair of the Ethics Committee will confirm that the incident is non-serious and report to the Committee at the next meeting. The final view of the Committee will be communicated to you.

Reporting Serious Adverse Events

The Ethics Committee should be notified of all serious adverse events via the Ethics Committee Administrator immediately the incident occurs. Where the adverse incident is unexpected and serious, the Chair or Vice-Chair will decide whether the study should be terminated pending the opinion of an independent expert. The adverse event will be considered at the next Committee meeting and a decision will be made on the need to change the information leaflet and/or study protocol.

On completion of the research you must submit a brief report (a maximum of two sides of A4) of your findings/concluding comments to the Committee, which includes in particular issues relating to the ethical implications of the research. With best wishes for the research.

Yours sincerely
Professor John ForemanChair of the UCL Research Ethics Committee

Cc: Danah Al Tarrah, Applicant

________________University College London Gower Street London WC1E 6BT Tel: ___________ Email: ethics@ucl.ac.uk http://ethics.grad.ucl.ac.uk/

Appendix J Ethical approval letter, UAEU

UAEU College of Medicine and Health Sciences

جامعة الإمارات العربية المتحدة
United Arab Emirates University

8th July 2014

Dr. Syed Shah
Associate Professor, Institute of Public Health,
College of Medicine and Health Sciences
UAE University

Dear Dr. Sayed,

Re: Al Ain Medical District Human Research Ethics Committee - Protocol No. 14/37-Preschool obesity in the United Arab Emirates: Determinants and the effectiveness of the 10 Steps Healthy Lifestyle Tool for Toddlers, Eat Right Emirates study.

Thank you very much for submitting your application to the Ethics Committee.

Your submitted documents were reviewed by the committee and I am pleased to provide you ethical approval of your project.

May I reiterate, should there be any ethical concern arising from the study in due course the Committee should be informed.

Annual reports plus a terminal report are necessary and the Committee would appreciate receiving copies of abstracts and publications should they arise.

I wish to take this opportunity to wish you success with this important study.

This Ethics Committee is an approved organization of Federal Wide Assurance (FWA) and compliant with ICH/GCP standards.

With kind regards,

Yours sincerely,

Dr. Fawaz Torab

Chair, Al Ain Medical District Human Research Ethics Committee

www.cmhs.uaeu.ac.ae www.cmhs.uaeu.ac.ae

Appendix K Study Invitation letter

مدارس الإمارات الوطنية
Emirates National Schools

UAEU College of Food and Agriculture

جامعة الإمارات العربية المتحدة
United Arab Emirates University

مجمع مدينة العين

Nutrition & Health Department

WHO Collaborating Center in Nutrition

قسم التغذية والصحة

Invitation دعـــوة

Title of Project: EAT RIGHT EMIRATES Study
Determinants of preschool obesity in Al Ain District, Abu Dhabi Emirate.
Name of Researcher: **Danah Al Tarrah**

Dear Parent,

In partnership with Emirates National School AlAin Campus of a study on obesity risk among preschool, We would now like to invite you and your child to take part in a new research study. The Eat Right Emirates study aims to study lifestyle factors to find out how they may affect obesity risk in young children aged 2-5 years. Lifestyle factors studied will include diet, physical activity and other behaviors. The study will be based at your child's school in Al Ain district, Abu Dhabi Emirate.

We would also like to test how well a new tool – Eat Right Emirates, 10 steps to a healthy lifestyle for Toddlers – can help parents and carers of preschool children make healthy food and lifestyle choices for their children. The Eat Right Emirates study will help to improve our understanding of how lifestyle factors affect the risk of overweight/obesity and heart disease. We hope that the findings from this study may identify ways to reduce the risk of heart disease in later life.

We have enclosed an information booklet giving details of the study and explaining what we would ask you and your child to do should you wish to take part. If you would like to know more about the study, or think you would like to take part, please could you fill in the attached form and join us at a briefing session. If you wish, you can also contact the researcher in charge of the study, Miss Danah Al Tarrah, by phone (Tel No: ____________________) for any further information.
We will telephone you over the next few days and look forward to talking to you and to answering any questions you may have. All information will be in the strictest confidence.

Thank you for taking the time to read this letter.
Yours sincerely,

الموضوع : تحديد السمنة لدى الأطفال في مدينة العين/ أبوظبي/ الإمارات **اسم الباحث :** دانه خالد الطراح

السيد ولي الأمرالفاضل/ الفاضلة

بالمشاركة مع مدرسة الامارات الوطنية في دراسة حول الحد من السمنة وتحديدها لدى الأطفال ،نود أن ندعوكم مع أطفالكم للمشاركة في دراسة **Eat Right Emirates** تهدف هذه الدراسة للتعرف على العوامل السلوكية المؤدية إلى السمنة و مخاطرها على الأطفال ما بين **2-5** سنوات في الإمارات العربية المتحدة. يشرف على هذه الدراسة مختصون في التغذية وطب المجتمع والصحة العامة في جامعة الإمارات العربية المتحدة.

وقد أظهرت الدراسات الحديثة أن السمنة تتشكل في مراحل مبكرة من العمر. لذا فإن هذه الدراسة ستعزز من فهمنا لسلوكيات الحياة التي تؤثر في زيادة الوزن أو السمنة مما يزيد من مخاطر الإصابة بأمراض القلب وغيرها من الأمراض المزمنة في مراحل متقدمة من العمر.
ونسعى من خلال هذه الدراسة **(Eat Right Emirates Study)** إلى تحقيق **10** خطوات ستساعد أولياء الأمور والمهتمين برعاية الأطفال في دور رياض الأطفال في اتخاذ خيارات غذائية وسلوكية أفضل لهم والتي نأمل من خلالها تعزيز الحياة الصحية .

معلومات عن تفاصيل الدراسة وشرح الأسئلة التي ستطرح على أطفالكم في المدرسة. لذا نرجو في حالة موافقتكم التوقيع على نموذج الموافقة المرفق مع هذه الدعوة.
وإذا رغبتم في معرفة المزيد عن هذه الدراسة فيمكنكم الاتصال بالباحث المسؤول عن الدراسة **الآنسة دانة الطراح** على هاتف رقم-________. علما أننا سنحاول الاتصال بكم هاتفيا خلال الأسابيع القليلة المقبلة وأتطلع إلى الحديث معكم و الإجابة على أية أسئلة قد تكون لديكم، علما بأن جميع المعلومات والبيانات سيتم تناولها بسرية تامة.

شكرا لكم ولحسن اهتمامكم .
تفضلوا بقبول فائق الاحترام والتقدير،،،

Appendix L Parent information

PARENT'S INFORMATION

Eat Right Emirates

Pre-School Study

Eat Right Emirates Pre-school Study

We would like to invite you and your child to participate in a research study. This information sheet provides you with information about the study, why it is being done, and what is required from you and your child.

Please read below the following information, and feel free to ask about any areas that are unclear, or if you wish to be provided with additional information. It is your own decision whether you wish for you and your child to take part in this research study. Please take time to read this sheet and discuss with family and friends before deciding whether you wish to take part.

Eat Right Emirates Pre-school Study

What is the aim of this study?

The Eat Right Emirates study aims to study lifestyle factors to find out how they may affect obesity risk among preschool children aged 2 - 5 years old in Al Ain district, Abu Dhabi Emirate. Lifestyle factors studied will include diet, physical activity and other behaviours. The study will also test a new tool; Eat Right Emirates: 10 steps for a healthy lifestyle for toddlers, designed to help parents or carers make healthy food and lifestyle choices for their preschool children.

We hope to find out from this study what factors are associated with overweight/obesity and heart disease. The findings may help identify ways to reduce the risk of obesity and heart disease in later life.

Why is the study being done?

Research has suggested that obesity starts from infancy and early childhood and that diet and other lifestyle factors established at this young age, shape future lifestyle choices and may increase the risk of obesity. Few studies have been done in the UAE, and therefore this study will provide essential information to guide prevention from childhood obesity.

How is the study being done?

Once the study has been explained to you at the school, you will be asked to sign a consent form, which will allow you and your child to take part in this study. You will be provided with a copy of the signed consent form for your own record.

The study will require you to attend the school on two occasions, at the start of the study and 6 months later. At both sessions measurements of your child will be carried out. We will also ask you to complete simple questionnaires asking about social and lifestyle factors such as diet and physical activity that may influence your child's risk of obesity.

Children and their parents will

Eat Right Emirates Pre-school Study

be put into one of two groups. One group will receive a leaflet and advice for a healthy lifestyle in toddlers (intervention group) and the other group will be provided with usual care (control group). These groups will be decided by a computer at random. All the measurements will be done at the start of the study and repeated after 6 months, in order to compare results.

Measurements

All the measurements are simple, painless and not in any way harmful. If you agree, we would like to:

a) Measure your and your child's height and weight and hip and waist circumferences.

b) Measure skinfold thickness, which involves measuring the thickness of a small fold of skin at four points: biceps (front upper arm); triceps (back upper arm); sub-scapular (below the shoulder blade) and supra-iliac (front of hip). Children will not be asked to undress completely.

c) Measure your and your child's blood pressure using an electronic monitor. This involves briefly inflating a cuff around the arm while the machine takes a measurement.

d) You will also be asked to complete a 5-day diet diary and appetite questionnaire about your child's normal eating habits, on 2 separate occasions during the study. If you agree, we would also like you to

Images used were purchased through Shutterstock complete a questionnaire about your usual eating habits.

e) You will be asked questions about your and your child's health, diet, physical activity, family history of disease and whether any medications are being taken. All questionnaires will be completed in a private room and results from the study will be confidential and anonymous.

After the last time you are seen by the researchers we would like to keep in contact with you so that we can continue to monitor your child. This long term follow-up will also allow us to find out the effects of the Eat Right Emirates intervention and allow us to monitor changes in body weight, dietary patterns and physical activity.

However we would once again explain the study and ask for your permission before we did any further tests.

Are there any risks and discomforts?

There are no risks involved in this study and all measurements taken are non-invasive.

Will my taking part in this study be kept confidential?

All data and measurements collected will be anonymous and confidential. Only researchers involved in the study and a representative of the Research Ethics Committee will have access to the information collected during this study.

What are the potential benefits?

The present study may not directly benefit your child. However, findings of the study will provide an understanding of lifestyle factors that may increase the risk of preschool obesity in the UAE and provide information for future preventative measures to reduce this risk.

Do I have to take part?

You don't have to participate in this study, and if you decide now or at a later stage that you and your child would not like to take part, you can freely withdraw from this research study.

Who is organising and funding the research?

The study is organised by the Institute of Public Health, College of Medicine and Health Sciences, United Arab Emirates University together with the Institute of Child Health, University College of London.

Who do I speak to if a problem arises?

If you have any complaints about this research project, Please feel free to discuss any queries with the head researcher. If any issues are not resolved or you wish to state your concern, please contact Dr Ayesha Al Dhaheri.

What are the arrangements for compensation?

This research has been approved by a Research Ethics Committee who believe that it is of minimal risk to your child. However, research can carry unforeseen risks and we want you to be informed of your rights in the unlikely event that any harm should occur as a result of taking part in this study.

This research is covered by a no-fault compensation scheme, which may apply in the event of any significant harm resulting to you or your child from involvement in the study. Under this scheme it would not be necessary for you to prove fault. You also have the right to claim damages in a court of law. This would require you to prove fault on the part of the Hospital/ Institute and/or any manufacturer involved.

What do I do if I would like to take part?

If you decide to take part in this study, please return the attached slip, or you can contact us by telephone o [redacted] or by email. If we [redacted] you, we may contact you to ensure that you have received the information letter, and discuss the study with you if you wish.

Details of how to contact the Researchers

[redacted]

United Arab Emirates University
Medicine and Health Sciences College
Institute of Public Health

*Images used were purchased through Shutterstock

معلومات ولي الأمر

Eat Right Emirates

دراسة عن مرحلة رياض الأطفال

نود دعوتكم مع أطفالكم للمشاركة في هذه الدراسة البحثية حيث تبين صحيفة المعلومات كافة المعلومات وبيانات الدراسة خاصة ما يتعلق بأهداف الدراسة والمطلوب منكم ومن أطفالكم.

يرجى التفضل بقراءة المعلومات الواردة أدناه كما يرجى عدم التردد في طرح أي تساؤلات لديكم أو في حالة رغبتكم بالحصول على معلومات إضافية، علما بأن القرار النهائي في المشاركة من عدمها يرجع إليكم ولأطفالكم. كما نقترح قراءة صحيفة المعلومات المرفقة ومناقشتها على مستوى العائلة والأقارب والأصدقاء قبل اتخاذ القرار بالمشاركة.

أهداف الدراسة:

الغذاء السليم - دراسة اماراتية تهدف إلى رصد وبحث العوامل السلوكية والكشف عن دورها في مخاطر السمنة لدى أطفال مرحلة رياض الأطفال (2-5 سنوات) في مدينة العين، إمارة أبو ظبي.

إن دراسة العوامل السلوكية ستشمل الحمية والنشاط البدني والسلوكيات الأخرى. وتسعى الدراسة (الغذاء السليم في الإمارات) إلى تحقيق 10 خطوات نمطية لصغار الأطفال والتي يمكن أن تساعد أولياء الأمور والمهتمين برعاية الأطفال رياض الأطفال في اتخاذ خيارات غذائية وسلوكية أفضل لأطفالهم. إن الدراسة سالفة الذكر ستعظم من فهمنا في العوامل المشتركة التي تؤثر في زيادة الوزن / السمنة وأمراض القلب.

ونأمل أن تسهم نتائج هذه الدراسة في تحديد سبل تفادي مخاطر الأصابة بأمراض القلب في وقت لاحق من حياتنا.

لماذا هذه الدراسة؟

إن الأبحاث تضمنت مؤشرات تدل على أن السمنة تبدأ من نعومة أظفار الأطفال وخلال فترة المهد وأن عوامل الحمية وأنماط السلوكية المؤثرة في هذا العمر المبكر يشكل أنماط السلوك المستقبلية للطفل والتي يمكن أن تسهم في مخاطر السمنة. علما أن هناك دراسات قد تم اجراؤها في الإمارات العربية المتحدة، إلا أن هذه الدراسة ستقدم معلومات أساسية التي يمكن من خلالها وجود تدخل مبكر للتعامل مع السمنة لدى الأطفال.

أسلوب تنفيذ الدراسة:

عند اعتماد الدراسة من قبل المدرسة، سيتم تزويدكم بنموذج «موافقة» من قبلكم تجيز مشاركتكم مع أطفالكم في الدراسة كما سيتم تزويدكم بنسخة من هذا النموذج للاحتفاظ به لديكم.

ستتطلب الدراسة حضوركم للمدرسة مرتين مرة مع بداية الدراسة وأخرى بعد ستة شهور. حيث سيتم خلال المرحلتين إجراء قياسات على أطفالكم تتألف من استبيانات مبسطة حول عوامل اجتماعية وسلوكية كالحمية والانشطة البدنية ذات العلاقة المؤثرة في مخاطر السمنة. وسيتم وضع الأطفال وأولياء أمورهم في مجموعة من مجموعتين؛ مجموعة تزود بارشادات

حول السلوك الصحي لدى صغار الأطفال، ومجموعة أخرى سيتم تزويدها بالرعاية الاعتيادية. وكلا المجموعتين سيتم رصدهما من خلال حاسب آلي عشوائيا، علما أن جميع القياسات التي ستتم في بداية الدراسة وستتكرر لاحقا تهدف إلى مقارنة النتائج.

القياسات:

جميع القياسات بسيطة ولا تتسبب بأي ازعاج أو ضرر. في حالة الموافقة سوف نقوم بالآتي:

1 - قياس طول ووزن ومحيط الخصر والحوض لولي الأمر والطفل.

2 - قياس سماكة ثنايا الجلد الذي سيشمل قياس سماكة الثنايا الصغيرة في أربعة أماكن: مقدمة أعلى الذراع، ومؤخرة أعلى الذراع، وتحت الكتف، ومقدمة الحوض. علما أنه ليس مطلوبا أن ينزع الأطفال ملابسهم بشكل كامل.

3 - قياس ضغط الدم لديكم ولدى أطفالكم بالأجهزة الإلكترونية الخاصة بقياس ضغط الدم من الذراع.

4 - كما سيطلب منكم ملء استبيان حول 5 أيام من الحمية والشهية للطفل وكذلك عن عادات تناول الطعام في مرحلتين منفصلتين خلال الدراسة. وفي حالة الموافقة يرجى ملء استبيان حول عادات تناول الطعام لديكم.

هل هناك أيه مخاطر أو أضرار؟

لا يوجد أية أضرار أو مخاطر في هذه الدراسة وفي جميع الاختبارات ذات الصلة.

هل مشاركتي في الدراسة ستبقى سرية؟

كل البيانات والقياسات التي سيتم جمعها ستبقى سرية تماما. ولن يطلع عليها سوى الباحثون ذوي العلاقة وكذلك ممثلي لجنة اخلاقيات البحوث.

ما هي الفوائد المتوقعة من الدراسة؟

بالرغم من أن الدراسة قد لا تفيد اطفالكم مباشرة الا ان نتائجها ستوفر فهما اعمقا لعوامل انماط الحياة التي تزيد من مخاطر السمنة في رياض الاطفال في دولة الامارات، كما انها ستساعد على توفير معلومات وبيانات للاجراءات الاحترازية الهادفة الى الحد من هذه المخاطر في المستقبل.

هل يتوجب عليكم المشاركة؟

لست مضطرا للمشاركة في الدراسة ولكم مطلق الحرية في الانسحاب في اي وقت تشاءون.

من الذي يمول هذه الدراسة البحثية؟

ينظم هذه الدراسة معهد الصحة العامة في كلية الطب والعلوم الصحية في جامعة الامارات العربية المتحدة بالتعاون مع معهد صحة الطفل التابع لجامعة لندن.

في حالة ظهور اي مشكلة مع من يمكنني التحدث؟

اذا برزت اي شكاوي من هذا المشروع البحثي، يرجى مناقشة التساؤلات مع الباحث الرئيسي وفي حالة عدم حل اية من هذه المشكلات يرجى مراجعة الدكتورة عائشة الظهيري.

5 - كما سيتم طرح أسئلة عليكم فيما يخص صحة أطفالكم والنظام الغذائي الخاص بهم والنشاط البدني وتاريخ العائلة المرضي والأدوية التي يتم تناولها، علما ان جميع الفحوصات والقياسات ستتم في غرف مغلقة وخاصة تتسم بالسرية المطلقة.

بعد أنتهاء كافة القياسات والفحوصات سنسعى إلى الاتصال بكم لمتابعة أطفالكم. ان هذه الإجراءات ستساعدنا على رصد المتغيرات المتعلقة بالوزن والأنشطة البدنية. وفي حالة الحاجة إلى القيام باختبارات وقياسات للفترة الثانية سيتم إخطاركم بذلك والحصول على موافقتكم عليها.

بيانات الباحثين :

جامعة الإمارات العربية المتحدة
كلية الطب والعلوم الصحية
معهد الصحة العامة

ماهي الترتيبات للتعويضات المالية؟

في ضوء موافقة لجنة اخلاقيات البحوث على هذا المشروع واعتبار وجود ادنى نسب المخاطر لطفلك من جراء المشاركة، يرجى العلم ان اي بحث قد ينتج عنه خطر ما لم يكن في الحسبان وعليه نود إخاطركم في حقكم بهذا الخصوص في اي تعويض قد يصيب اطفالكم جراء مشاركتكم في هذا البحث.

ان هذا البحث يغطيه تأمين التعويض ضد الخطأ الذي قد يصيب اطفالكم او يصيبكم جراء مشاركتكم في هذا البحث. وفي هذه الحالة ليس من الضروري اثبات من هو المخطئ. ويحق لكم اللجوء إلى القضاء في طلب التعويض، الأمر الذي يتعين عليه اثبات مصدر الخطأ اما المستشفى او المعهد ام المنتج ذا العلاقة.

ماذا افعل لكي اشارك؟

اذا قررتم المشاركة املأ النموذج المرفق وسلمه لنا او اتصل بالهاتف رقم . او عبر البريد الالكتروني:

واذا لم نستلم ردك يتم الاتصال للتأكد من استلامكم لرسالتنا ومناقشة الدراسة اذا رغبتم.

Appendix M Consent form (English and Arabic)

UAEU College of Food and Agriculture
Nutrition & Health Department
WHO Collaborating Center in Nutrition

جامعة الإمارات العربية المتحدة
United Arab Emirates University
قسم التغذية والصحة

CONSENT FORM

Title of Project: EAT RIGHT EMIRATES Study: Determinants of preschool obesity in Al Ain District, Abu Dhabi Emirate.

Name of Researcher: **Danah Al Tarrah**

Please initial box

1. I confirm that I have read and understand the information sheet dated for the above study and have had the opportunity to ask questions. ☐
2. I understand that mine and my child's participation is voluntary and that I can feely withdraw at any time, without giving any reason, without my medical care or legal rights being affected. ☐
3. I agree, along with my child to take part in the above study. ☐
4. I understand that my data will be kept confidential and in a safe place ☐

______________________	______________	__________________
Name of Parent	Date	Signature

Contact Number: ___________________________________

E-mail:____

______________________	______________	__________________
Name of Child	Signature (Parents)	Date
______________________	______________	__________________
Researcher	Signature	Date

UAEU College of Food and Agriculture
Nutrition & Health Department
WHO Collaborating Center in Nutrition

جامعة الإمارات العربية المتحدة
United Arab Emirates University
قسم التغذية والصحة

نموذج موافقة

الموضوع : Eat Right Emirates Study تحديد السمنة لدى الأطفال في مدينة العين/ أبوظبي/ الإمارات .

اسم الباحث : دانه خالد الطراح

- ١ أقر أنا ....الموقع أدناه بأنني قرأت واطلعت على كافة التفاصيل الموضحة في صحيفة المعلومات و أتيحت لي فرصة النقاش .
- ٢ اقر بأن مشاركتي و كذلك طفلي تأتي بإرادتنا و تطوعيا وأنه يمكن الانسحاب في أي وقت دون إبداء الأسباب و دون المساس بسجلي الطبي و حقوقي القانونية.
- ٣ أوافق أنا شخصيا و طفلي أيضا على المشاركة في الدراسة البحثية.
- ٤ أعلم بأن كافة البيانات سيتم التعامل معها بسرية تامة و في مكان آمن.

اسم ولي الأمر:.............................

التوقيع: ....

التاريخ:................................

رقم الهاتف..

البريد الإلكتروني..

اسم الطفل: .... **التوقيع** (ولي الامر):........................ **التاريخ:** ....

اسم الباحث: .... **التوقيع:** ....**التاريخ:**..............................

Appendix N Five day food diary (English and Arabic)

Sample of day five day food diary presented below

Food Diary

Eat Right Emirates Study

Study number

ERE ☐☐☐☐☐☐

Please remember to bring the completed diary with you the next time you visit the training centre

If you have any problems filling out the diary please do not hesitate to contact Danah

Tel: __________________

Please remember:

1) To start recording from you child's next main meal.

2) For the next day, begin recording after midnight. For example, if you were recording today, this would include a drink if your child awoke during the night.

3) Record all formula feeds by stating the amount made up in ounces and the amount left at the end of the feed.

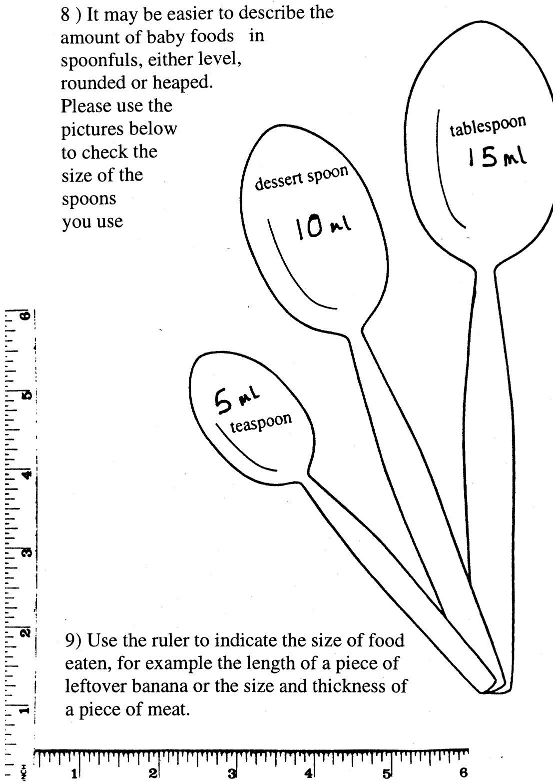
4) Please give details of how you make up bottles: brand name e.g. scoops of milk powder plus volume of water added.

5) Please give as much detail as you can about the brand of food eaten, for example: give examples of current baby foods here. When using dried baby foods please describe how much dried food was used before adding water or milk.

6) If you cook some dishes at home, please provide as much detail as you can on the pages provided at the back of this diary.

7) To help us to measure the portion of food eaten by your child we ask you to describe the food in handy measures, for example: number of spoonfuls of cereal, a thin slice of bread spread thickly or thinly with butter/spread, a potato the size of an egg.

8) It may be easier to describe the amount of baby foods in spoonfuls, either level, rounded or heaped. Please use the pictures below to check the size of the spoons you use



9) Use the ruler to indicate the size of food eaten, for example the length of a piece of leftover banana or the size and thickness of a piece of meat.

Example: Morning

Time	Food/drink items	Serving size	Amount left
breakfast	Scrambled egg White toast (Golden loaf) Butter (Nadec) Strawberry jam (Hero) Aptamil white milk (made up 9 scoops and 250ml of water)	5 level tbsps 1 med slice thick spread thick spread 250ml	2 level tsps left crusts 110ml
midmorning	Butter cookies (Americana) Fruit Cocktail (Al Rabie) (250 ml bottle with 30 ml juice and 220ml water) banana	1 330ml 1 medium	none 100ml 4 cm
lunch	1 cup of rice with chicken (1/4 breast) Strawberry pudding (Safio Danino) (125g pot) chocolate cake (size: 2cm x3cm) (+/- icing/filling) Aptamil White milk (6 scoops of powder and 170 ml water)	1 cup 170ml	2 level tsps none left icing 30ml

Morning Day 1 _________

Time	Food/drink items	Serving size	Amount left
breakfast			
midmorning			
lunch			

Afternoon Day 1 ________

Time	Food/drink items	Serving size	Amount left
Midafternoon			
Teatime			
Evening			
Bedtime			

Morning Day 2_________

Time	Food/drink items	Serving size	Amount left
breakfast			
midmorning			
lunch			

Afternoon Day 2 ________

Time	Food/drink items	Serving size	Amount left
Midafternoon			
Teatime			
Evening			
Bedtime			

Recipes

Please record any recipes you use on these pages following the example below

No	Day	Meal	Ingredients	Amount or weight
1	Monday	Lunch	Chicken Machboos (serves 2) water chicken stock cube olive oil chicken legs skinless dried lime (loomi) saffron onion chopped tomato chopped garlic clove minced cinnamon powder tumeric powder curry powder salt basmati rice	 2 cups 1 stock cube 1 tbsp 3 1 1/8 tsp 1 small 1 small 1 small ¼ tsp ½ tsp ½ tsp ½ tsp 1 cup

Please give as much detail as you can about ingredients and indicate amount of them (you can estimate by using spoons, cups or describing size). For example: cheddar cheese, grated, 3tbsp, or chicken breast, 3 medium portions, skinless. Can you also describe how much salt, sugar, oil etc is added.

When batch cooking and freezing, it's useful for us to know how much of a recipe fits into the container you store it in e.g. ice cubes. If possible, could you measure the numbers of spoonfuls in each cube and keep a record with the recipe.

Recipes

No	Day	Meal	Ingredients	Amount or weight

سجل الأكل

Eat Right
Emirates Study

رقم الدراسة

ERE ☐☐☐☐☐☐

يرجى التأكد من إحضار سجل الأكل بالكامل خلال زيارتكم القادمة لمركز التدريب.

اذا كانت لديكم بعض المشاكل في تعبئة نموذج السجل، يمكنكم الاتصال بالآنسة الباحثة دانه الطراح على الهاتف : 0553654430

يرجى التذكير :

١ - لابد من تسجيل الوجبة القادمة لطفلك.

٢ - يتـم التسجيل في نهايـة اليوم بالليل. مثـلا إذا كان التسجيل يتم اليوم فهذا يعني نفس اليوم و يشمل ذلك الشرب حين يكون طفلك صاحيا.

٣ - تسجيـل جميـع الاكلات و تحديد الحجم و القياسـات و كذلك ما يتبقى من الاكل.

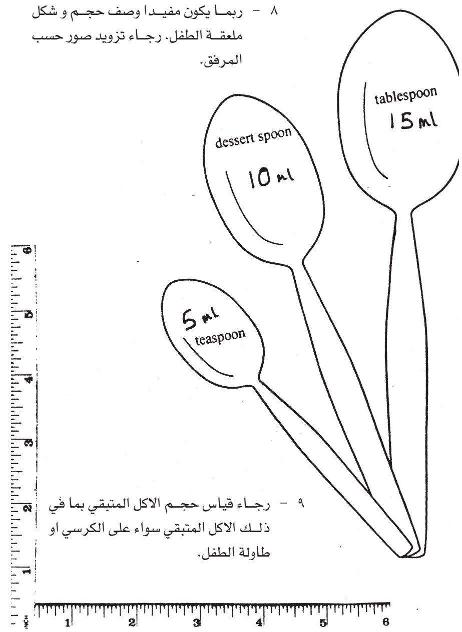
٤ - رجـاء تزويدي بتفاصيل بكيفية تحضيـر الزجاجة و الماركة مثلا ملاعق حليب البودر و نسبة الماء.

٥ - رجـاء تزويـد كل التفاصيل عـن ماركة الاكل : مثـلا اعطاء امثلة لـلاكل الذي يتم تناوله. كما يرجـى تحديد ووصف الاكل الناشف قبل اضافة الماء.

٦ - فـي حالة الطبخ فـي البيت ، رجاء تزويدنـا بالتفاصيل في خاتمة سجل الاكل.

٧ - من اجل مساعدتنا على التعرف على كافة التفاصيل رجاء التدقيق في رصد عدد الواجبات من خبز وبيض وزبدة و بطاط و بيض.

٨ - ربمـا يكون مفيـدا وصف حجـم و شكل ملعقـة الطفل. رجـاء تزويد صور حسب المرفق.



٩ - رجـاء قياس حجـم الاكل المتبقي بما في ذلـك الاكل المتبقي سواء على الكرسي او طاولة الطفل.

مثال: صباحاً

الوقت	الاكل / الشرب	القياس والحجم	الاكل المتبقي
صباح	بيض مخفوق	٥ معالق اكل	٢ معالق اكل
	توست ابيض	نصف قطعة	
	زبدة (ناداك)	مسح غزير	حواف متبقية
	مربى فراولة (هيرو)	مسح غزير	
	ابتاميل –حليب	٠٥٢ ميلي	٠١١ ميلي
وسط اليوم	بسكويت بالزبدة (أمريكانا)	١	–
	كوكتيل فواكه (الربيع)	٠٣٣ ميلي	٠٠١ ميلي
	موز	متوسطة الحجم	
الغداء	كـوب مـن الرز مـع ربـع دجاجة (صدر)	كوب واحد	ملعقتان
	حلوى الفراولة ١٢٥ جم		–
	كيكـة الشوكولاتـه مقاسـ ٢سم×٣سم		
	حليـب أبيض أوبتيمـل (٦ملاعق ممسوحة و١٧٠ مل ماء)	١٧٠مل	٣٠ مل

صباحاً اليوم الأول ________________

الوقت	الاكل / الشرب	القياس والحجم	الاكل المتبقي
صباحاً			
وسط اليوم			
الغداء			

صباحاً اليوم الثاني ________________

الوقت	الاكل / الشرب	القياس والحجم	الاكل المتبقي
صباحاً			
وسط اليوم			
الغداء			

بعد الظهر اليوم الأول ________________

الوقت	الاكل / الشرب	القياس والحجم	الاكل المتبقي
وسط البعد الظهر			
وقت الشاي			
مساءً			
وقت النوم			

بعد الظهر اليوم الثاني ________________

الوقت	الاكل / الشرب	القياس والحجم	الاكل المتبقي
وسط البعد الظهر			
وقت الشاي			
مساءً			
وقت النوم			

وصفات:

رجاء تدوين أي وصفات تستخدمها في الصفحات التابعة للمثال التالي:

رقم	اليوم	الوجبة	المكونات	الكمية أو الوزن
١	الاثنين	الغداء	مجبوس دجاج	
			ماء	٢ كوب
			مكعب ستيك دجاج	١ ستيك
			زيت زيتون	مكعب
			فخذ دجاج بدون جلد	١
			ليمون مجفف (لومي)	٣
			زعفران	١
			بصل مفروم	٨/١ ملعقة شاي
			طماطم مفرومة	١ صغيرة
			فص ثوم مفروم	١ صغير
			قرفة مطحونة	١ صغيرة
			كركم مطحون	٤/١ ملعقة شاي
			كاري مطحون	٢/١ ملعقة شاي
			ملح	٢/١ ملعقة شاي
			أرز بسمتي	١ كوب

رجاء إعطاءنا تفاصيل أكثر بقدر ما تستطيع عن المكونات ومقاديرها (تستطيع تقديرها باستخدام الملاعق، الأكواب، أو وصف الحجم) . مثال على ذلك: جبنة التشيدر، تفرم، ٣ ملاعق شاي، أو صدر دجاج، ٣ أجزاء متوسطة، بدون جلد. تستيطع أيضا وصف كمية الملح، السكر، الزيت ..الخ المضافة.

عندما تطهو كمية من الطعام وتفرزها، من المفيد لنا أن نعرف المدة المناسبة للتخزين مثال مكعبات الثلج. إذا أمكن، ممكن أن تحدد عدد الملاعق المليئة في كل مكعب وسجلها مع الوصفة.

وصفات:

رقم	اليوم	الوجبة	المكونات	الكمية أو الوزن

Appendix O Baseline study questionnaires

EAT RIGHT EMIRATES STUDY Id ERE

Draft

Today's date __ / __ / 20__

CHECKLIST: BASELINE Yes=1 No= 0

- Consent ☐
- Screening measurements (Weight & Height) ☐
- Anthropometry ☐
- Vascular Data ☐
- Dietary and Behaviour Related Questionnaire ☐
- Medical & Pregnancy & Birth Data ☐
- Social Data ☐
- Smoking Data ☐
- 5 Day Food Diary ☐
- Explain blinding ☐
- Leaflet given ☐

EAT RIGHT EMIRATES STUDY Id ERE

Draft

Today's date __ / __ / 20__ Sex O Male O Female

BASELINE

National no.

Child's surname

Child's first name

Child's date of birth __ / __ / 20__ Age (yrs.mths) __.__

Mother's surname

Mother's first name

Father's Surname

Carer's Name

Relationship to Child

Home Address

Post code

Home telephone number (+code)

Work telephone number (+code)

Mobile

email

EAT RIGHT EMIRATES STUDY Id ERE

Draft

Ethnic origin

Please tick the box that you think best describes your child's ethnic origin

- White O
- Arabic O
- Indian O
- Pakistani O
- Bangladeshi O
- Asian-other O
- Black-African O
- Black-other O
- Chinese O
- Other O
- Refused O

If 'other' how would you describe your child's ethnicity?

EAT RIGHT EMIRATES STUDY Id ERE

Draft

SOCIAL DATA

How many children live in the family home?

How many are mother's own children?

Please give details of other children in the family

	Date of birth	Age	Sex
Child 1	__ / __ / ____	__.__ yrs mths	☐ M=1, F=2
Child 2	__ / __ / ____	__.__ yrs mths	☐ M=1, F=2
Child 3	__ / __ / ____	__.__ yrs mths	☐ M=1, F=2
Child 4	__ / __ / ____	__.__ yrs mths	☐ M=1, F=2
Child 5	__ / __ / ____	__.__ yrs mths	☐ M=1, F=2

Can we contact you in the future ? (Yes=1 No=0) ☐

Notes

EAT RIGHT EMIRATES STUDY Id ERE

Draft

SOCIAL DATA

How many children live in the family home?

How many are mother's own children?

Please give details of other children in the family

Child 1 Date of birth / / Age . yrs mths Sex M=1, F=2

Child 2 Date of birth / / Age . yrs mths Sex M=1, F=2

Child 3 Date of birth / / Age . yrs mths Sex M=1, F=2

Child 4 Date of birth / / Age . yrs mths Sex M=1, F=2

Child 5 Date of birth / / Age . yrs mths Sex M=1, F=2

Can we contact you in the future ? (Yes=1 No=0)

Notes

EAT RIGHT EMIRATES STUDY Id ERE

Draft

SOCIAL DATA

Yes=1 No=0

Does the child attend:

School nursery How many sessions per week?

Playgroup Length of session (hrs mins) .

Is the child looked after by;

Childminder Half days; how many? Full days; how many?

Family member Half days; how many? Full days; how many?

EAT RIGHT EMIATES STUDY Id ERE

Draft

Today's date / /

BASELINE

SMOKING Yes=1 No=0

Have you ever smoked a cigarette? Has your partner ever smoked a cigarette?

If yes, do you smoke regularly? If yes, do they smoke regularly?

If you smoke, how many per day? If they smoke, how many per day?

How long have you been smoking for? (yrs.mths)

How many days since you last smoked a cigarette?

How long has your partner been smoking for? (yrs.mths)

How many days since your partner last smoked a cigarette?

Do you smoke another type of smoke?

If you smoke, how many per day?

EAT RIGHT EMIRATES STUDY Id ERE

Draft

PREGNANCY & BIRTH

Today's date / / 20 **Yes=1 No=0**

Total number of pregnancies Was this pregnancy achieved via IVF?

Were there any complications with this pregnancy?

Was pre-eclampsia diagnosed? Was diabetes diagnosed?

Was toxaemia diagnosed? Was hypertension diagnosed?

Please give details of any other complications in pregnancy

Number of weeks gestation (measured via scan) . (To nearest day if known)

How did labour commence? ○ Spontaneous ○ Induced ○ Irrelevant

How was this child delivered?
- ○ NVD
- ○ elective LSCS
- ○ Emergency LSCS
- ○ Forceps
- ○ Missing

EAT RIGHT EMIRATES STUDY Id ERE

Draft

PREGNANCY & BIRTH

Did the child spend time in NNU? O Yes O No If yes how long was child in NNU? Days

Was the child ventilated? O Yes O No If yes, for how long? Days

Was the child treated for jaundice? O No O Yes (untreated) O Yes (treated)

Was the child treated for infections (given a/b's) O Yes O No

Did your child require surgery immediately following birth for any of the following:
(1 = yes, 0= no)

lung heart GI tract liver kidney

Please give brief details of surgery

Did your child require medical treatment following birth for any of the following:
(1 = yes, 0= no)

lung heart GI tract liver kidney

Please give brief details of medical treatment

How long did the child spend in hospital following birth? Days

Please specify any other medical problems immediately following birth:

1.

2.

3.

EAT RIGHT EMIRATES STUDY Id ERE

Draft

PREGNANCY & BIRTH

Birth order in family (livebirths)

O 1st born

O 2nd born

O 3rd born

O 4th born

O 5th born

What was this child's birthweight? grams

What time was this child born? : e.g.H12:10 1hrs

EAT RIGHT EMIRATES STUDY Id ERE

Draft

Infant feeding during 1st year of life

This section asks how the child was fed during the first year of life answer 1 for yes, 0 for no.

Did you breast feed? Age started weeks Age stopped

Special formula fed? Age started weeks Age stopped

Regular formula fed? Age started weeks Age stopped

Cow's milk given? Age started weeks Age stopped

Was other milk given? Age started weeks Age stopped

Please name other milks used

At what age were you first given "solid" foods? weeks

Was sibling 1 Breastfed ? (yes=1 No=0)

Was sibling 2 Breastfed ? (yes=1 No=0)

Was sibling 3 Breastfed ? (yes=1 No=0)

Was sibling 4 Breastfed ? (yes=1 No=0)

EAT RIGHT EMIRATES STUDY Id ERE

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MEDICAL HISTORY
BASELINE

Family history of other disease:

With respect to subject (not parent) code, code 0 for no disease:

1 - mother	2 - father
3 - brother	4 - sister
5 - maternal grandmother	6 - maternal grandfather
7 - paternal grandmother	8 - paternal grandfather

High Cholesterol

Heart disease

Overweight

Hypertension

Diabetes - non-insulin dependant

Diabetes - insulin dependant

Has your child ever required surgery for any of the following:
(1 = yes, 0= no)

lung heart GI tract liver kidney

Please give details of any surgery in childhood

Has your child ever required medical treatment for any of the following:
(1 = yes, 0= no)

lung heart GI tract liver kidney

Please give details of any medical treatment in childhood

EAT RIGHT EMIRATES STUDY

Draft

Id E R E

EXERCISE QUESTIONNAIRE

BASELINE

How many hours per week does your child spend watching TV and videos, plus playing on the computer and video games (Mon - Fri only)

And at weekends?

How many hours in total watching TV or playing video games?

Does your child do any of the following on a regular basis through the week?

Riding bike . Swim . Football .

Dancing . Gymnastics . Trampolining .

Going to the park . Walking . Other sport .

Other, please specify

How often do you do play (physically) with your child?

- O everyday
- O three times per week
- O Most days
- O Weekends only

How much time is spent playing with your child each week?

- O 1 hour
- O 1 - 5 hours
- O More than 5 hours

How many hours in total do you spend in exercise?

Parent's opinion

Total hours child spents in vigorous activity per week

Level of child's activity compared to peers
(N.B. compared with others in same age group not only child's friends as these will probably be similar in activity level)

1= much less than peers
2= less
3= same
4= more

EAT RIGHT EMIRATES STUDY

Draft

Id E R E

ANTHROPOMETRY

BASELINE

Mother's Height . cm Mother's Weight . kg

Actual ○ Reported ○ Pregnant ○

Father's Height . cm Father's Weight . kg

Actual ○ Reported ○

EAT RIGHT EMIRATES

Children's Behaviour Questionnaire

BASELINE

Date / /

General Behaviour

Please answer the following questions about your child's behaviour in the past two weeks...

In general my child	1	2	3	4	5	6	7	8	9	10	
Is miserable	○	○	○	○	○	○	○	○	○	○	Is happy
Gets upset easily,is overemotional	○	○	○	○	○	○	○	○	○	○	Does not get upset easily
Is quiet	○	○	○	○	○	○	○	○	○	○	Is communicative
Has problems with sleeping	○	○	○	○	○	○	○	○	○	○	Sleeps well
Is difficult to manage, disobedient	○	○	○	○	○	○	○	○	○	○	Is easy to manage
Is restless/overactive	○	○	○	○	○	○	○	○	○	○	Is calm/peaceful
Worries parent a lot	○	○	○	○	○	○	○	○	○	○	Does not worry parents
Plays alone	○	○	○	○	○	○	○	○	○	○	Enjoys playing with others
Demands attention	○	○	○	○	○	○	○	○	○	○	Is easy going
Has some difficulties with siblings/other children	○	○	○	○	○	○	○	○	○	○	Gets on well with siblings/other children

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

BASELINE

Date / /

Please answer the following questions about your child's behaviour in the past two weeks...

Activity - related behaviour

My child....	1	2	3	4	5	6	7	8	9	10	
Is passive	○	○	○	○	○	○	○	○	○	○	Is active
Tires easily	○	○	○	○	○	○	○	○	○	○	Is full of energy
Watches TV, DVD's, plays TV games a little	○	○	○	○	○	○	○	○	○	○	Watches TV, DVD's, plays TV games a lot
Spends little time playing	○	○	○	○	○	○	○	○	○	○	Spends a lot of time playing

Food - related behaviour

My child....	1	2	3	4	5	6	7	8	9	10	
Is difficult to feed	○	○	○	○	○	○	○	○	○	○	Is easy to feed
Is active during meals	○	○	○	○	○	○	○	○	○	○	Is calm during meals
Is distracted during meals	○	○	○	○	○	○	○	○	○	○	Pays attention to meals
Finishes meals very quickly	○	○	○	○	○	○	○	○	○	○	Eats slowly

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

BASELINE

Date __ / __ / ____

Please answer the following questions about your child's behaviour in the past two weeks...

Food - related behaviour cont'd

My child	1	2	3	4	5	6	7	8	9	10	
Has a small appetite	○	○	○	○	○	○	○	○	○	○	Has a big appetite
Is full before the meal is finished	○	○	○	○	○	○	○	○	○	○	Is not full before finishing
Is always asking for food	○	○	○	○	○	○	○	○	○	○	Eats at meal and snack times
Is always asking for a drink	○	○	○	○	○	○	○	○	○	○	Drinks when offered the drink
Leaves food on a plate at the end of a meal	○	○	○	○	○	○	○	○	○	○	Leaves no food on plate at the end of a meal
Difficult to please with meals	○	○	○	○	○	○	○	○	○	○	Enjoys meals
Refuses new foods	○	○	○	○	○	○	○	○	○	○	Enjoys tasting new foods
Likes only few selected foods	○	○	○	○	○	○	○	○	○	○	Enjoys a wide variety of foods
Does not like eating vegetables	○	○	○	○	○	○	○	○	○	○	Enjoys eating vegetables
Does not like eating fruit	○	○	○	○	○	○	○	○	○	○	Enjoys eating fruit

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

BASELINE

Date __ / __ / ____

Please answer the following questions about your child's behaviour in the past two weeks...

How much time did you spend playing with your child each day?	○ 0-1hrs	○ 2-3 hrs	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs
How much time did your child spend watching TV/video/DVD each day ?	○ 0-1hrs	○ 2-3 hrs	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs
How many hours did your child sleep each night?	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs	○ 10-11hrs	○ more than 12 hrs
How many helpings of fruit did your child eat ach day?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many types of fruit did your child eat regularly every day ?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many types of vegetables did your child eat regularly every day?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many snacks does your child usually have each day?	○ 0-1	○ 2-3	○ 4-5	○ 6-7	○ more than 7

What is your child's usual snack?

What is your child's usual non-milk drink?

How many bottles/cups of milk does your child drink each day?

Thankyou for taking the time to complete this questionnaire

Draft

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

ANTHROPOMETRY

Date today __ / __ / 20__

BASELINE

Height (cm)	___._	Weight (kg)	___.__
MUAC (cm)	___._	Head circum (cm)	___._
Waist circum (cm)	___._	Hips (cm)	___._
Thigh circum (CM)	___._	Calf circum (cm)	___._

BMI (wt(kg) / ht(m) x ht(m)) ___._

Skinfold Thickness Measurements

Biceps (mm)	___._	___._	___._
Triceps (mm)	___._	___._	___._
Subscap (mm)	___._	___._	___._
Supra-iliac (mm)	___._	___._	___._

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

VASCULAR DATA

Today' s date __ / __ / ____

BASELINE

Room Temperature __._ celcius

Nb: After sitting or lying supine for 10 mins

	Systolic	Diastolic	HR
Blood pressure reading 1			
Blood pressure reading 2			
Blood pressure reading 3			

Appendix P Follow-up study questionnaires

Draft

EAT RIGHT EMIRATES STUDY Id E R E

Today's date __ / __ / 2 0 __

CHECKLIST: Follow-up (6months) Yes=1 No= 0

- Social Data ☐
- Smoking Data ☐
- Dietary and Behaviour Related Questionnaire ☐
- Vascular Data ☐
- Anthropometry ☐
- 5 Day Food Diary ☐
- Medical & Pregnancy & Birth Data ☐
- Leaflet returned ☐

Draft

EAT RIGHT EMIRATES STUDY Id E R E

Today's date __ / __ / 2 0 __ Sex O Male O Female

Follow up (6months)

Child's surname

Child's first name

Child's date of birth __ / __ / 2 0 __

Yes=1 No=0

Is your child well today? ☐

If no, reason:

Has your child required medical treatment since September ? ☐

If Yes.... ☐

Has your child started taking any vitamins or medication? ☐

If Yes.... ☐

Have you changed your accommodation since September ? ☐

If Yes.... ☐

Have you or your partner changed your job since September ? ☐

If Yes.... ☐

Is the child looked after by;

Childminder ☐ Half days; how many? ☐ Full days; how many? ☐

Family member ☐ Half days; how many? ☐ Full days; how many? ☐

Draft

EAT RIGHT EMIRATES STUDY Id E R E

FOLLOW UP (6 MONTHS)

SMOKING Yes=1 No=0

Have your your smoking habits changed? ☐ If yes, do you smoke regularly? ☐

If you smoke, how many per day?

How many days since you last smoked a cigarette?

Have your partner's smoking habits changed? ☐

If yes, does your partner smoke regularly? ☐

How many days since your partner last smoked a cigarette?

Draft

EAT RIGHT EMIRATES STUDY Id E R E

EXERCISE QUESTIONNAIRE

Follow up (6 months)

How many hours per week does your child spend watching TV and videos, plus playing on the computer and video games (Mon - Fri only)

And at weekends?

How many hours in total watching TV or playing video games?

Does your child do any of the following on a regular basis through the week?

Riding bike . Swim . Football .

Dancing . Gymnastics . Trampolining .

Going to the park . Walking . Other sport .

Other, please specify

How often do you do play (physically) with your child?

- O everyday
- O three times per week
- O Most days
- O Weekends only

How much time is spent playing with your child each week?

- O 1 hour
- O 1 - 5 hours
- O More than 5 hours

How many hours in total do you spend in exercise?

Parent's opinion

Total hours child spents in vigorous activity per week

Level of child's activity compared to peers

(N.B. compared with others in same age group not only child's friends as these will probably be similar in activity level)

1= much less than peers
2= less
3= same
4= more
5= much more

EAT RIGHT EMIRATES STUDY

Children's Behaviour Questionnaire

Id E R E

Follow up (6months)

General Behaviour

Please answer the following questions about your child's behaviour in the past two weeks...

In general my child	1	2	3	4	5	6	7	8	9	10	
Is miserable											Is happy
Gets upset easily,is overemotional											Does not get upset easily
Is quiet											Is communicative
Has problems with sleeping											Sleeps well
Is difficult to manage, disobedient											Is easy to manage
Is restless/overactive											Is calm/peaceful
Worries parent a lot											Does not worry parents
Plays alone											Enjoys playing with others
Demands attention											Is easy going
Has some difficulties with siblings/other children											Gets on well with siblings/other children

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

Follow up (6 months)

Please answer the following questions about your child's behaviour in the past two weeks...

Activity - related behaviour

My child....	1	2	3	4	5	6	7	8	9	10	
Is passive											Is active
Tires easily											Is full of energy
Watches TV, DVD's, plays TV games a little											Watches TV, DVD's, plays TV games a lot
Spends little time playing											Spends a lot of time playing

Food - related behaviour

My child....	1	2	3	4	5	6	7	8	9	10	
Is difficult to feed											Is easy to feed
Is active during meals											Is calm during meals
Is distracted during meals											Pays attention to meals
Finishes meals very quickly											Eats slowly

Draft

EAT RIGHT EMIRATES STUDY

Id E R E

EAT RIGHT EMIRATES (10 STEP LEAFLET RESULTS) Questionnaire

Date __ / __ / ____

Please mark onthe scale what best desscribes your child's current behaviour compared with starting ERE

Food related

	Disagree strongly 1	2	3	4	5	6	7	8	9	10 Agree strongly
Eats more fruit										
Eats more vegetables										
Eats more types of fruit										
Eats more types of vegetables										
Enjoys eating fruit										
Enjoys eating vegetables										
Drinks less fizzy and sugary drinks										
Eats fewer salty and spicy snacks										
Asks to have more fruit and vegetables										
Prefers to have fruit for snacks										

Draft

Page 1

EAT RIGHT EMIRATES STUDY

Id E R E

Follow up (6 months)

Please answer the following questions about your child's behaviour in the past two weeks...

Food - related behaviour cont'd

My child	1	2	3	4	5	6	7	8	9	10	
Has a small appetite											Has a big appetite
Is full before the meal is finished											Is not full before finishing
Is always asking for food											Eats at meal and snack times
Is always asking for a drink											Drinks when offered the drink
Leaves food on a plate at the end of a meal											Leaves no food on plate at the end of a meal
Difficult to please with meals											Enjoys meals
Refuses new foods											Enjoys tasting new foods
Likes only few selected foods											Enjoys a wide variety of foods
Does not like eating vegetables											Enjoys eating vegetables
Does not like eating fruit											Enjoys eating fruit

Draft

EAT RIGHT EMIRATES STUDY

Id | E | R | E | | | |

Follow up (6 months)

Please answer the following questions about your child's behaviour in the past two weeks...

How much time did you spend playing with your child each day?	○ 0-1hrs	○ 2-3 hrs	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs
How much time did your child spend watching TV/video/DVD each day ?	○ 0-1hrs	○ 2-3 hrs	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs
How many hours did your child sleep each night?	○ 4-5 hrs	○ 6-7 hrs	○ 8-9 hrs	○ 10-11hrs	○ more than 12 hrs
How many helpings of fruit did your child eat ach day?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many types of fruit did your child eat regularly every day ?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many types of vegetables did your child eat regularly every day?	○ 0-1	○ 2-3	○ 4-5	○ more than 5	
How many snacks does your child usually have each day?	○ 0-1	○ 2-3	○ 4-5	○ 6-7	○ more than 7

What is your child's usual snack?

What is your child's usual non-milk drink?

How many bottles/cups of milk does your child drink each day?

Draft

Thankyou for taking the time to complete this questionnaire

EAT RIGHT EMIRATES STUDY

Id | E | R | E | | | |

Results Questionnaire

Date __ / __ / ____

Please mark onthe scale what best desscribes your child's current behaviour compared with starting ERE

General behaviour

	Disagree strongly 1	2	3	4	5	6	7	8	9	10 Agree strongly
Is happier	○	○	○	○	○	○	○	○	○	○
Is more confident	○	○	○	○	○	○	○	○	○	○
Is less fussy	○	○	○	○	○	○	○	○	○	○

Health related

	1	2	3	4	5	6	7	8	9	10
Has fewer health problems	○	○	○	○	○	○	○	○	○	○
Has fewer visits to the GP	○	○	○	○	○	○	○	○	○	○

Draft

EAT RIGHT EMIRATES STUDY

Id | E | R | E | | | |

Results Questionnaire

Date __ / __ / ____

Parent observations

	Disagree strongly 1	2	3	4	5	6	7	8	9	10 Agree strongly
I can manage my child's behaviour better	○	○	○	○	○	○	○	○	○	○
I can cope better with fussy eating at meal times	○	○	○	○	○	○	○	○	○	○
Meal times are more structured and routine	○	○	○	○	○	○	○	○	○	○
I can understand food portion sizes better	○	○	○	○	○	○	○	○	○	○
I am able to understand food labels better	○	○	○	○	○	○	○	○	○	○
I have improved my own eating habits	○	○	○	○	○	○	○	○	○	○
I believe i am a better role model for my child	○	○	○	○	○	○	○	○	○	○
I think my relationship with my child has improved	○	○	○	○	○	○	○	○	○	○
I feel that i have benefitted from the programme	○	○	○	○	○	○	○	○	○	○
I feel my child has benefited from the programme	○	○	○	○	○	○	○	○	○	○

	1	2	3	4	5	6	7	8	9	10
Can you please rate how useful you found the 10 Steps ERE leaflet	○	○	○	○	○	○	○	○	○	○

Draft

Please comment

EAT RIGHT EMIRATES STUDY Id E R E

Draft

ANTHROPOMETRY

Date today __ / __ / 20__

FOLLOW UP (6 months)

Height (cm) ___.__ Weight (kg) ___.__

MUAC (cm) ___.__

Waist circum (cm) ___.__

Hips (cm) ___.__

BMI (wt(kg) / ht(m) x ht(m)) ___.__

Skinfold Thickness Measurements

Biceps (mm) ___.__ ___.__ ___.__

Triceps (mm) ___.__ ___.__ ___.__

Subscap (mm) ___.__ ___.__ ___.__

Supra-iliac (mm) ___.__ ___.__ ___.__

EAT RIGHT EMIRATES STUDY Id E R E

Draft

VASCULAR DATA

FOLLOW UP (6months)

Today' s date __ / __ / ____

Room Temperature __.__ celcius

Nb: After sitting or lying supine for 10 mins

	Systolic	Diastolic	HR
Blood pressure reading 1			
Blood pressure reading 2			
Blood pressure reading 3			

EAT RIGHT EMIRATES STUDY Id E R E

Draft

ANTHROPOMETRY

Follow up (6 months)

Mother's Height ___.__ cm Mother's Weight ___.__ kg

Actual ◯ Reported ◯ Pregnant ◯

Father's Height ___.__ cm Father's Weight ___.__ kg

Actual ◯ Reported ◯

EAT RIGHT EMIRATES STUDY Id E R E

Draft

Parents Perception

(Yes=1 No=0)

Do you consider your child is at a healthy weight? ☐

If yes, reason:

Do you think your child is overweight? ☐

If yes, reason:

Do you think your child is underweight? ☐

If yes, reason:

Does culture play a role in the weight status of a child? ☐

If yes, reason:

Appendix Q Eat Right Emirates tool

EAT RIGHT EMIRATES

Ten steps for healthy toddlers

Good habits for health, growth and development

Adapted from: 10 steps for Healthy toddlers (Infant and Toddler forum)

1 Eat together as a family and make meal times relaxed, happy occasions

Make food easy to eat – Finger food are good

Eat the food that you would like your toddler to eat.

Praise your toddler when he or she eats well or tries something new – toddlers take time to learn to like new foods, don't stop trying.

2 You decide which nutritious foods to offer but let your toddler decide how much to eat

Never insist your toddler eats everything on his or her plate.

3 Offer food from all 5 food groups each day

Together they give the right mix of nutrients your toddler needs (see the helpful guide).

4 Have a routine and offer 3 meals and 2 - 3 snacks each day

Offer 2 courses at each meal and only offer nutritious snacks.

Don't allow grazing on food all day.

5 Offer 6 - 8 drinks a day

Give all drinks in a cup 100 - 120 ml is about right. Water is a good choice, and dilute fruit juices.

6 Give vitamins A & D each day

Choose a vitamin supplement suitable for toddlers – most toddlers don't get enough in their food. Ensure safe exposure to the sun using sunscreen, for vitamin D.

7 Respect your toddler's tastes and preferences – don't force feed

Understand that some children eat almost everything while others are much more picky.

Some like foods kept separate at a meal and others are happy with food mixed in together.

8 Reward your toddler with your attention – never give food or drink as a reward, treat or for comfort.

Play, read or talk with your toddler as a reward. Always give fruit or a nutritious pudding – don't use it as reward for eating other foods first or for good behaviour

9 Limit...

Fried food, crisps, packet snacks, pastries, cakes and biscuits to small amounts.

Sweet food to four times a day e.g. as part of the three meals and one snack.

...and avoid

Sweetened fruit squashes, fizzy drinks, tea and coffee.

Undiluted fruit juices – only give juice well diluted at meal times.

Whole nuts, which may cause choking.

10 Encourage physical activity for at least 3 hours every day and about 12 hours sleep.

All activity such as active play inside or outside, walking, running and dancing counts. Limit TV and other screen time like computers to just 1 hour a day.

Helpful guide showing you the Five Food Groups

Bread, rice, potatoes, pasta and other starchy foods. - Offer at each meal and at some snacks - Choose whole grain options	½ - 1 slice whole grain bread or ½ -1 Chapatti or ¼ - ½ pita bread 3 - 6 heaped Tbs whole grain or fortified breakfast cereals without sugar, sweeten naturally with dried or fresh fruit 5 - 8 Tbs of hot cereals like porridge made with milk. 2 - 5 Tbs of rice or pasta 1 mini (70g) pizza ½ to 1 ½ egg sized potatoes or 1 - 4 Tbs of mashed potato ½ - 1 Vegetable/cheese samousa (1 - 2 small samousa)
Fruits and vegetables - Offer at each meal and at some snacks.	¼ - ½ medium apple or orange ¼ - ¾ pear or ¼-1 medium banana 3 - 10 small berries or grapes 1 small bowl vegetable/lentil soup (90 - 125ml) 1 - 3 Tbs raw or cooked vegetables, especially dark green, orange and
Milk, cheese and yogurt - 3 toddler portions per day - No bottles of milk	100 - 120 ml, whole cow's milk as a drink in a cup. 1 small pot (125ml) yogurt 2 - 4 Tbs grated cheese : Cheese in a sandwich or on a piece of pizza 4 - 6 Tbs milk pudding (Mahalabiya) Give whole milk rather than lower fat milks from 12 months of age until at least 2 years of age.
Meat, fish, eggs, nuts and pulses - 2 to 3 toddler portions per day	2 - 4 Tbs ground, chopped or cubed lean meats, fish or poultry (2 - 4 pieces kebab) ½ - 1 chicken drumstick (e.g. in machboos) ½ - 1 whole egg 2 - 4 Tbs whole lentils, dahl, chickpeas (e.g. Nukhi) 1 - 2 Tbs Hummus 1 - 3 small falafels ½ - 1 Tbs peanut butter 1 - 2 Tbs ground or chopped nuts
Food and drinks high in fat and sugar - Only include very small amounts	½ - 1 digestive biscuit 1 - 2 small biscuits 1 small sliced cake 1 Tsp butter, oil or 1 - 2 Tsp mayonnaise 1 Tsp jam, honey or sugar 4 - 6 crisps or 2 - 4 sweets (fruit gums) 1 small fun-sized chocolate bar (e.g. Kit kat, Mars, Twix)

Tbs - Tablespoon , Tsp - Teaspoon

دليل صحي يبيّن مجموعات الغذاء الخمسة

الخبز، الأرز، البطاطس، الباستا وغيرها من المأكولات النشوية. - قدّمي في كل وجبة رئيسية وفي بعض الوجبات الخفيفة - اختاري الأطعمة ذات الحبة الكاملة	½ إلى شريحة من الخبز كامل الحبة أو ½ إلى 1 شريحة شباتي أو ¼ إلى ½ رغيف خبز 3 - 6 ملاعق من حبوب كاملة أو حبوب الإفطار بدون سكر المحلاة طبيعياً بفاكهة طازجة أو مجففة 5 - 8 ملاعق من حبوب الإفطار الساخنة مثل الشعير المعد بالحليب 2 - 5 ملاعق من الأرز أو الباستا بيتزا صغيرة (70غ) ½ إلى 1 ½ حبة بطاطس بحجم البيضة أو 1 - 4 ملاعق بطاطس مهروسة ½ إلى 1 سمبوسك خضروات أو جبن (1 - 2 سمبوسك صغيرة الحجم)
الفاكهة والخضروات - قدميها في كل وجبة رئيسية وفي بعض الوجبات الخفيفة	¼ إلى ½ تفاحة أو برتقالة متوسطة الحجم ¼ إلى ¾ حبة كمثرى أو ¼ إلى 1 حبة موز متوسطة الحجم 3 - 10 حبات توت أو عنب صغيرة صحن صغير من شوربة الخضروات أو العدس (90 - 125 مل) 1 - 3 ملاعق من الخضروات الطازجة أو المطبوخة خاصة الخضراء الداكنة أو البرتقالية اللون.
الحليب، الأجبان والزبادي - 3 كميات صغيرة يومياً - لا تستخدمي زجاجات الحليب	100 - 120 مل حليب بقري كامل في كوب قدر صغير (125 مل) من الزبادي 2 - 4 ملاعق من الجبن المبشور: جبن في ساندوتش أو قطعة بيتزا 4 - 6 ملاعق من المهلبية استخدمي الحليب كامل الدسم بدلاً من قليل الدسم بداية من سن 12 شهر حتى العام الثاني لطفلك.
اللحوم، الأسماك، البيض، المكسرات والبقوليات - مرتين إلى 3 مرات بكميات صغيرة يومياً	2 - 4 ملاعق من اللحم، السمك أو الدجاج المفروم، المقطع أو المهروس ½ إلى 1 قطعة دجاج (مثل المكبوس) ½ إلى 1 بيضة كاملة 2 - 4 ملاعق عدس، حمص الأصفر أو الجريش (مثل النخي) 1 - 2 ملاعق حمّص 1 - 3 حبات فلافل ½ إلى 1 ملعقة زبدة فول سوداني 1 - 2 ملاعق مكسرات مطحونة أو مقطعة
المأكولات والمشروبات ذات الدهون والسكريات العالية - قدمي كميات صغيرة جداً منها	½ إلى 1 بسكويت دايجستيف 1 - 2 بسكويت صغير قطعة كيك صغيرة ملعقة صغيرة زبدة أو زيت، أو 1 - 2 ملعقة مايونيز ملعقة صغيرة مربى، عسل أو سكر 4 - 6 قطع مقرمشات أو 2 - 4 قطع حلويات (حلويات المضغ بالفاكهة) لوح شوكولاتة صغيرة (مثل كيت كات أو مارس أو تويكس)

EAT RIGHT EMIRATES

عشر خطوات لأطفال أصحاء

عادات سليمة لصحة، نمو وتطوّر جيد

مقتبسة من: 10 خطوات لأطفال أصحّاء (منتدى الرضّع والأطفال)

1 تناول الطعام معاً كأسرة واجعلي أوقات الوجبات مناسبات مريحة وسعيدة

ليكن الطعام أسهل في تناوله مثل الأطعمة المطبوخة على شكل أصابع ولقيمات. تناولي الطعام الذي تودين أن يأكله أبناؤك. امدحيهم عندما ينهون طعامهم أو جربي وصفات جديدة ولا تيأسي من المحاولات فالأطفال يستغرقون وقتاً ليعتادوا على الأطعمة الجديدة.

2 أنت من يقرّر الأطعمة المفيدة تقدّميها لكن امنحي أطفالك فرصة اختيار كميتها

لا تصرّي على أن يأكل طفلك كل شيء في صحنه.

3 قدّمي الطعام من تختلف مجموعات الطعام الخمسة يومياً

توفر تلك المجموعات المزيج الصحي والمناسب للتغذية السليمة التي يحتاجها طفلك. (اطّلعي على الدليل الصحي)

4 التزمي بنظام معين وقدّمي 3 وجبات رئيسية ووجبتين خفيفتين إلى 3 يومياً

لتكن الوجبة مكونة من طبقين أما الوجبة الخفيفة تكون مفيدة غذائية.

لا تسمحي لهم بإلتهام الطعام طوال اليوم.

5 اجعليهم يشربون السوائل 6 - 8 مرات يومياً

قدّمي المشروبات في كوب سعته 100 - 120 مل، مثل الماء وعصائر الفاكهة المخففة.

6 امنحيهم فيتامينات (أ) و (د) يومياً

اختاري مكملاً غذائياً يناسب احتياجات أطفالك، فمعظمهم لا يحصل على ما يكفيه. اضمني حصولهم على فيتامين د من خلال تعرّضهم الصحي للشمس باستخدام واقي للشمس.

7 احترمي ذوق أطفالك واختياراتهم، ولا تجبريهم على تناول الطعام

تفهّمي طبيعة أن بعض الأطفال يتناولون كل شيء تقريباً بنما ينتقي البعض الآخر ما يأكلونه، كما أن بعضهم يحب أن يمزج الطعام كلّه والبعض الآخر يفضل أن يفصل أطعمة عن غيرها.

8 امنحي طفلك الاهتمام وكافئيه بالراحة أو اللعب وليس بالطعام أو المشروبات

إلعبي مع طفلك، اقرئي معه أو تحدثا سوياً كنوع من المكافأة. اجعليه يتناول الفاكهة أو الحلويات الغنية بالمواد الغذائية ولكن ليس كنوع من المكافأة بأن يتناولها قبل أطعمة معينة أو لسلوك حميد فعله.

9 اقتصدي في..

تناول المأكولات المحمّرة، المقرمشات، الوجبات الخفيفة المعلّبة، المعجنات، الكيك والبسكويت. خفّفي من تناول الحلويات لأربع مرات يومياً، كجزء من الوجبات الثلاثة الرئيسية ووجبة خفيفة واحدة على سبيل المثال.

... وتجنبي مشروبات الفاكهة المحلاة، المشروبات الغازية، الشاي والقهوة، قدّمي لهم عصائر الفاكهة المخففة وقت الطعام.

10 شجّعيهم على ممارسة أي نشاط جسماني لمدة 3 ساعات يومياً على الأقل وأن يحصلوا على حوالي 12 ساعة من النوم

يمكنهم ممارسة أي نشاط مثل اللعب داخل أو خارج المنزل، المشي، الركض أو الرقص. خفّفي من مشاهدتهم للتلفزيون وغيرها من الأجهزة ذات الشاشات مثل الكمبيوتر لتكون لمدة ساعة واحدة يومياً.

Appendix R Control leaflet

Appendix S Conferences and Courses

Conferences/symposiums presented at during PhD, and published abstract

- 2nd Annual Bright Start Woman and Children Health conference, Abu Dhabi, 16 November 2015.

- British Dietetic Association (BDA) Research Symposium, 2nd December 2015, presented abstract findings in the paediatric stream.

  Abstract published: AlTarrah D., Singhal A., Lanigan J. (2016). Evaluation of a simple tool (Eat Right Emirates) that aims to educate parents on healthy lifestyle practices – findings of a randomised controlled trial. *Journal of Human Nutrition and Dietetics*. 29, S1, 14–23.

Poster presentation and achievements

- Presented at UCL Doctoral School Research Poster Competition 2015/2016 (March) Poster title: evaluation of a simple healthy lifestyle tool "Eat Right Emirates" findings of a Randomised Controlled Trial.

- Presented at UCL Great Ormond Street Institute of Child Health Annual Poster competition 2016 – attained 2nd prize in the Population Policy and Practice category. Poster title: evaluation of a simple healthy lifestyle tool "Eat Right Emirates" findings of a Randomised Controlled Trial (dietary results)

Courses

- Dietary assessment methods workshop at the Nutrition Society, 10 May 2017